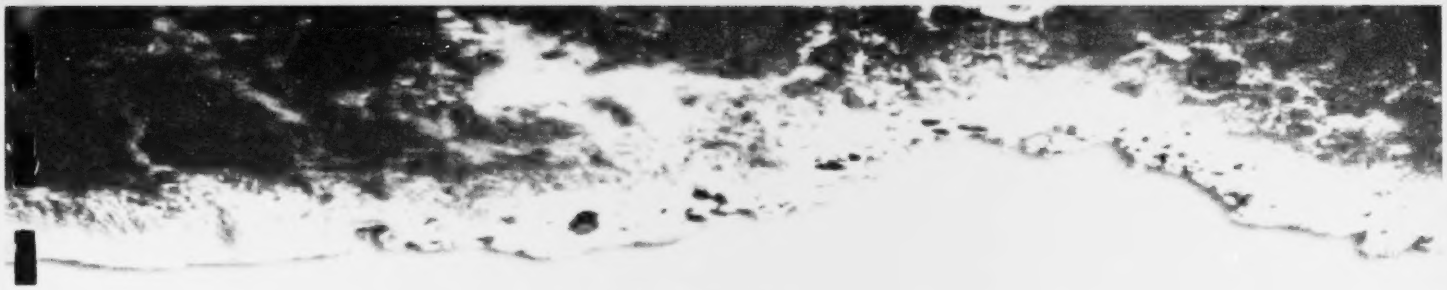

FISH PLANT EFFLUENTS: A WORKSHOP ON SUSTAINABILITY

Edited by

C. J. Morry, M. Chadwick, S. Courtenay and P. Mallet

Oceans and Science Branch
Fisheries and Oceans Canada
343 Université Ave.
Moncton, N.B.
E1C 9B6
morrycj@dfo-mpo.gc.ca

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E1C 9B6
morrycj@dfo-mpo.gc.ca

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ABSTRACT

Morry, C., Chadwick, M., Courtenay, S. and P. Mallet, editors. 2003. Fish plant effluents: A workshop on sustainability. Can. Ind. Rep. Fish. Aquat. Sci. 271: viii + 106 p

In partnership with Environment Canada, the New Brunswick Department of Environment and Local Government, and the New Brunswick Department of Agriculture Fisheries and Aquaculture, Fisheries and Oceans Canada organised a workshop at the Université de Moncton Shippagan Campus on February 25-26, 2003 to address the growing problems caused by fish plant effluents in the Gulf Region. The workshop examined the status of the industry across Atlantic Canada, some of the observed environmental effects of the industry, the regulations controlling those impacts and the technologies that exist to improve the industry's environmental profile. Attention was focussed first on conventional and easily instituted improvements in water conservation and product recovery within the plant as well as a variety of pollution prevention technologies. But the workshop also looked into more novel and innovative strategies, including uses in which nutrient-enriched fish plant effluents might be beneficially employed as a raw material. The workshop was attended by a full spectrum of participants and resulted in a strong common commitment to make the outcome of the discussions that took place the beginning of a co-operative process to implement improvements in environmental effects related to seafood processing.

RÉSUMÉ

Morry, C., Chadwick, M., Courtenay, S. and P. Mallet, editors. 2003. Fish plant effluents: A workshop on sustainability. Can. Ind. Rep. Fish. Aquat. Sci. 271: viii + 106 p

Dans le cadre d'un partenariat avec Environnement Canada, avec le ministère de l'Environnement et des Gouvernements locaux du Nouveau-Brunswick, et avec le ministère de l'Agriculture, des Pêches et de l'Aquaculture du Nouveau-Brunswick, Pêches et Océans Canada a organisé un atelier à l'Université de Moncton, campus de Shippagan, les 25 et 26 février 2003, afin d'aborder les problèmes de plus en plus pressants liés aux effluents des usines de transformation du poisson dans le golfe du Saint-Laurent. Il y a été question notamment de l'état de l'industrie dans toute la région de l'Atlantique, des incidences environnementales qui ont été observées, des règlements qui régissent ces incidences ainsi que des technologies qui existent pour améliorer le profil environnemental de l'industrie. Les participants à l'atelier ont d'abord discuté des techniques conventionnelles et faciles à mettre en œuvre pour la conservation de l'eau et l'extraction maximale du produit dans l'usine, ainsi que de diverses technologies de prévention de la pollution. Ensuite, ils ont abordé des stratégies nouvelles et modernes, par exemple des techniques qui permettraient l'utilisation des effluents d'usines de traitement du poisson enrichis de substances nutritives comme matière première. Les participants à l'atelier représentaient la gamme complète de groupes d'intérêt sociaux et tous se sont engagés fermement à faire en sorte que les discussions soient le début d'une action concertée pour apporter des améliorations.

PREFACE

In the early 1970s, the Fish Processing Operations Liquid Effluent Guidelines were promulgated under the *Canada Fisheries Act* as a stop-gap measure to provide some measure of control over the effects of fish plant operations along the coast. In the immediate wake of the announcement of these voluntary measures, workshops and training sessions were held across Canada to outline the issues and to recommend the application of the Guidelines and other measures for the sake of nearby receiving environments. At the time, little thought was given to potential human health impacts, though these have certainly arisen in subsequent years. Over the years, some provinces have also stipulated standards of this nature in their licensing requirements for fish plants but they have invariably drawn heavily upon the federal guidelines to avoid inconsistency.

Since that time, little has been done to either assess the individual and cumulative impact of fish plant operations or to identify suitable standards for their effluents and measures to achieve these standards. In the meantime, virtually every other land-based source of marine pollution has fallen under increasingly strict controls. At the federal legislative level, examples include mandatory regulations governing the food processing sector, pulp and paper mills, mines and milling operations, all made pursuant to the *Canada Fisheries Act*. There are also stringent control measures of a more general nature under the *Canadian Environmental Protection Act* and the *Canadian Environmental Assessment Act*. Similar safeguards exist at the provincial level in most jurisdictions.

One can speculate on the reasons for this obvious oversight in the federal regulatory net. Fish plant effluents are largely organic in nature and the traditional view has been that returning to the ocean what came from the ocean could do no harm. Then there was the now discredited belief that the oceans are vast and have an unlimited capacity to absorb any amount of organic waste material. These explanations, based as they were upon inherent misunderstandings of the potential environmental consequences of fish plant effluents, only serve to strengthen the need to take action without further delay.

In the absence of regulations to guide and control the industry, incidents that have arisen have required taking legal action after the fact under the provisions of Section 36 (Deposit of Deleterious Substances) and Section 35 (Harmful Alteration, Disruption or Destruction of Fish Habitat). Such remedies are never satisfactory for anyone concerned because, by the time such action is taken, the environment is already harmed. Moreover, regardless of the court decision in the legal action, any subsequent improvement in the status quo is not a certainty. Restoring damaged habitat is a great deal more difficult and costly than preventing the damage in the first place.

Ideally, it should be possible to work with the industry to prevent such problems from occurring. Often times, the stumbling block is not technical but economic. There are numerous commercially available technologies that remove particulates, Total Suspended Solids (TSS), and nutrients (Potassium- and Nitrogen-based compounds), and to reduce

Biological and Chemical Oxygen Demand (BOD/COD). Generally speaking, more than one method is needed to treat the effluent to acceptable standards (levels that will lead to an improvement in the condition of the receiving environment). For example, one commonly recommended method, Dissolved Air Flotation (DAF), is relatively inexpensive and is highly effective at removal of TSS and BOD/COD, but does little to reduce levels of ammonia and nitrates and other nutrients that can lead to oxygen depletion in the receiving environment. Biological treatment systems designed to remove the excess nutrient loading are a great deal more expensive and technically more complex than a DAF system.

The cumulative cost of installing multi-stage treatment systems that deal with all elements of concern in a large-scale fish plant operation can be equivalent to the cost of installing tertiary sewage treatment for a small town. Such costs are prohibitive for many plant operators. As a rule, fish plants in Canada sell most of their product abroad and compete, therefore, with processors in countries where labour costs are lower and environmental controls may be negligible or non-existent. To ask them to absorb such costs could put them at a competitive disadvantage that might require them to move their Canadian operations elsewhere. Furthermore, consistency of treatment within Canada is imperative if one plant operation is not to be left at a competitive disadvantage compared to others.

All of these issues demand a solution that goes beyond simply changing laws and regulations. This needs to be done in the long term to be sure. But any new regulations need to provide for control measures that are realistic from an economic standpoint and effective from the environmental standpoint. This will require further work to identify low cost improvements that can be implemented immediately. New, unconventional and low-technology methods may be practical, once proven in pilot scale testing. Ideally, such methods should begin by recovering as much of the product as possible and then exploiting the remaining waste stream as a nutrient raw material to produce fish meal or other secondary products, thus returning savings to the operation through sale of additional product.

A number of possibilities have been explored in hypothetical or academic terms but have not been commercially proven. Other potential solutions exist in Canada and other parts of the world, but have not been tested in Atlantic Canada. A starting point is the development and application of locally appropriate best management practices (BMPs), something that has not been undertaken to date. This requires careful examination of the tools available and their applicability in the local context. Going beyond that, there is a need to examine more innovative ideas which may include:

- using excess nutrient loading to promote growth and harvesting of a commercially valuable marine plant species, e.g. Irish moss (*Chondrus crispus*), dulse (*Palmaria palmata*), nori (*Porphyra spp.*);
- similarly, taking advantage of the filter-feeding capacity of commercially harvested shellfish, e.g. mussels (*Mytilus edulis*), oysters (*Crassostrea virginica*) in a form of polyculture with the above or on their own;

- concentrating the nutrients and combining them with an inert fibre such as peat to produce a commercially saleable compost or growing medium.

The list of potential solutions is a good deal longer than the few examples cited above. The concept needs to be fleshed out further through debate among fish plant operators, environmental control consultants, academics and scientists in both university and government. Not to be forgotten in this dialogue is the voice of the community itself. Not only do they have the most to gain from improvements of this kind, but they may also have ideas that could lead to unconventional solutions.

It was against this backdrop that the idea evolved to hold a small workshop, focussing initially on a specific environment of the Gulf coast of New Brunswick, in order to identify techniques worthy of further research and pilot scale testing. Participants would need to include representatives from the fish processing industry, government, environmental consulting and technologies, community groups, environmental non-governmental organisations, and centres for research and development and higher education.

With this objective in mind, Fisheries and Oceans Canada, Environment Canada, the New Brunswick Department of Environment and Local Government, and the New Brunswick Department of Agriculture Fisheries and Aquaculture decided to organise this workshop as the first step. The goal was to identify solutions for improved in-plant processes and effluent controls in the fish plants of New Brunswick Gulf coast. The full list of the workshop co-ordinating committee is found in Appendix D. In addition to the four government departments named above (which each provided either a co-champion or staff support) it included representatives of the New Brunswick Seafood Processors Association, the University of Moncton (Shippagan Campus), the University of New Brunswick, the National Research Council's Industrial Research Assistance Programme (IRAP), and the Marine Products Research and Development Centre Inc. (MPRDC) in Shippagan. The agenda of the workshop is included as Appendix E.

Not entirely by coincidence, the regional working group of the National Programme of Action (NPA) for the Protection of the Marine Environment from Land-Based Activities had just begun a programme of studies aimed at combating the nutrient enrichment problems associated with fish plants. And so it became an obvious liaison that the two processes should work in partnership and a representative of that group was invited to give the first technical presentation of the workshop.

The report which follows represents the results of that workshop.

EXECUTIVE SUMMARY

The issue of fish plant effluents and how they are affecting nearby coastal environments in the southern Gulf of St. Lawrence has attracted an increasing amount of public concern in recent years. Fish plants in the Gulf Region and across Canada are perhaps the least examined sources of marine environmental effects.

Scientists and managers at Fisheries and Oceans know this is not a simple situation to address. There are scientific and technical unknowns, as well as legal and jurisdictional issues that tend to complicate efforts to improve the current situation. From an industrial standpoint, economic realities related to the global market in which the industry operates can make changes difficult to implement.

In February 2003, a workshop was held in Shippagan, N.B. to bring together those with knowledge and an interest in this issue.

Mike Chadwick, Oceans and Science Director at DFO, opened the workshop by offering this reminder to the participants "Any problem we address today requires a team of people from all sectors and a multi-disciplinary approach."

The goal of the workshop was to focus on ways of dealing with excess nutrients found in the waste effluent streams of seafood processing plants and, in the words of participant Graham Daborn of Acadia University, to "Fix the problem, not the blame."

The composition of effluents varies tremendously, depending on the species being processed. Many participants agreed that the best approach was to recover and, if possible, make use of this organic matter (and therefore many of the nutrients), early in the process. "End of pipe treatment is the most expensive way to deal with the problem," noted Andy Woyewoda of the National Research Council. "It makes more sense to address it early by recovering solids, reducing water use and by segregating high-load streams for more advanced and more expensive biological and chemical treatment." Nadia Tchoukanova from the Marine Products Research and Development Centre in Shippagan agreed: "For each dollar you spend on prevention, you save five dollars of treatment."

In addition to exploring ways to improve in-plant and end of pipe conventional controls (reduce, reuse, recycle), workshop participants looked at the potential of using these nutrients as a beneficial by-product, rather than a pollutant to be contended with.

Paul Bourke of Trident Seafoods explained how their processing plant in Ucluelet, B.C. bought second-hand, food-grade spinning decanters to separate solids. He observed that it took only 40 days for the decanters to pay for themselves, since the fish paste recovered was used to make surimi. Bourke also mentioned the interesting results they found after doing a water audit at the plant; they discovered they used more water for cleaning than for processing.

Bourke also discussed how a task force was created to come up with ways to reduce water use and minimise waste. Working with a variety of partners from industry and the community, he says the process took time, but in the end, worked. The task force met once a month for three years and hired an engineer to write a guide on how to do an audit and how to better manage seafood-processing plants. A workshop was also held to share information on best practices. His conclusion from these experiences is a lesson he offers to the industry across Canada: "Preventing water pollution is a non-competitive issue."

Closer to home, research and development on issues of this kind has led to significant development in technologies that hold great potential for improvements in the fish-processing sector. In examining some of these methods, Thierry Chopin from the University of New Brunswick reminded participants that "The solution to nitrification is not dilution but conversion." A number of aquaculture techniques, such as the growth of valued algae or molluscs in the nutrient-rich environments surrounding salmon cage aquaculture, may hold potential for application as part of the solution to reusing nutrients in fish plant effluents. Similarly a number of local firms, in co-operation with groups like the Centre for Marine Product R&D at the Shippagan Campus of l'Université de Moncton, are developing recovery systems that produce food-grade products from organic waste. It only remains to demonstrate their effectiveness in the fish processing sector.

At the conclusion of the Shippagan conference, several participants agreed to participate in a working group to follow-up on these leads and to develop a pilot project or projects that could help minimise the impact of seafood processing effluents in the southern Gulf of St. Lawrence. In addition, Canadian and world-wide experience in the application of best management practices for water conservation, product retention and pollution prevention which are more rigorous than those covered by existing federal guidelines will be brought together by DFO in co-operation with the industry to offer plant owners low-cost solutions that have immediate applicability.

1.0 INTRODUCTION

Purpose of Workshop

The stage was set for the discussions that took place at the workshop by the opening remarks of the three co-champions, Mike Chadwick, Department of Fisheries and Oceans Canada (DFO), George Lindsay, Environment Canada (EC), and George Haines, New Brunswick Department of Environment and Local Government (NBDELG).

It was noted that this is really the first opportunity that has presented itself for all the concerned interests to get all the issues on the table and come to a better understanding of this complex problem. The outcome was expected to be proportional to the level of participation by all those in attendance and thus they were encouraged to take part actively in the discussions.

The issue of regulations and guidelines pertaining to fish plant operations hasn't really been looked at seriously since the 1970s. At that time, no regulations came forward, only guidelines, and these only addressed a few of the major concerns. Many changes have occurred since then in terms of public perceptions concerning the environment, within the industry itself, and in our expectations concerning the multiple uses of our coasts. These changes require us to re-examine the situation as it currently exists. Thanks to the fact that all the stakeholders involved were represented at the workshop it was possible for a true open multidisciplinary process to take place.

The objectives of the workshop were laid out:

1. To learn more about the industry, the regulations that govern it, the environment in which it operates and the public's concerns
2. to begin a dialogue on the issues of concern by understanding each other's point of view, by breaking down barriers to communication and by forming networks for future interaction
3. to put in place pilot projects on interesting technologies and potential by-products that may help improve the environmental profile of the industry.

The presentations arranged for the workshop were intended to bring everyone up to a common level of understanding of the environmental, industrial and regulatory issues associated with fish plant effluents. A number of presentations outlined conventional technological methods that have been tried in this or similar industrial settings and the achieved results. Others examined more unusual and experimental methods that may hold prospects for application in this industrial and environmental context.

At the end of the workshop the most important product was to create an action plan so that the discussions that took place would form the starting point for a process of renewal in the industry.

The purpose in developing such a common plan of action was:

- to provide for an ongoing working relationship to build and maintain momentum in tackling the problem;
- to lead to ideas on pilot testing of a suite of potentially interesting methods;
- and to recommend improved guidelines for in-plant conservation and pollution prevention that are relevant in New Brunswick and that are immediately applicable.

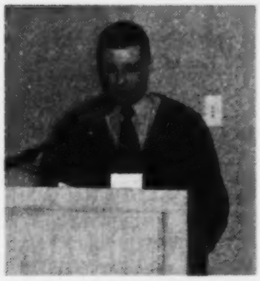
Mike Chadwick

George Lindsay

George Haines

2.0 SETTING THE STAGE

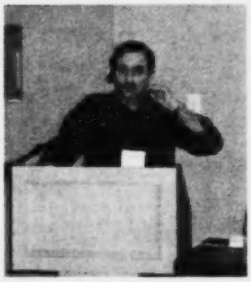
What are the impacts of fish plants on coastal environments of the southern Gulf of St. Lawrence?



Chair: Louis Arsenault

To create a common understanding of the issues involved, a number of invited presentations described current knowledge on fish plants in Atlantic Canada, environmental effects of these plants, the industrial and economic context in which the fish plant industry operates and the regulatory framework applied at present in New Brunswick. Each presentation includes a brief biological sketch of the speaker, an abstract of their presentation and a summary of the question and answer period that followed their presentation.

2.1 Management of seafood processing waste in the Atlantic Region. Jeffrey Corkum (Environmental Protection Branch, Environment Canada Atlantic Region)



Biographical Sketch

Jeffrey L. Corkum is the Head of the Pollution Control Section in the Environmental Protection Branch of Environment Canada's Atlantic Region based in Halifax, Nova Scotia. He holds degrees in Fuels and Materials Engineering from Royal Military College of Canada, and a Master Degree in Metallurgy and Materials Science from McMaster University. Jeffrey has 23 years of experience working in the federal government, including 13 years of military service. In his current position, Jeffrey is the lead authority for Environment Canada on a study of fish plants in Atlantic Canada under the auspices of the National Programme of Action (NPA) for the Protection of the Marine Environment from Land-based Activities. This multi-year study will characterise the industry in terms of its geographic distribution, production, and effluent characteristics and will examine methods of instituting Best Management Practices (BMP) and Pollution Prevention (P2) protocols across the industry.

Abstract

In the Atlantic Region, nutrient enrichment from land-based activities has been identified as a priority area for action. Sources of excess nutrients (principally nitrogen and phosphorus) include food processing, municipal and industrial wastewater, agricultural fertilizer runoff, nutrient-enriched groundwater, aquaculture operations, and soil erosion from agricultural and forestry practices. Nutrients are released into the marine environment through point sources, such as municipal and industrial discharges, and through non-point sources associated with agriculture.

The potential exists for eutrophication of coastal waters in all of the Atlantic Region. The contribution of nitrogen is of particular significance, as this is often a "rate limiting nutrient" in the marine environment. Excessive phytoplankton and macroalgal growth can cause serious water and aquatic habitat problems. The decay of massive quantities of plant material, particularly sea lettuce (*Ulva lactuca*), results in oxygen depletion and the production of toxic gases such as hydrogen sulphide and ammonia.

Seafood processing has been identified as one of the food processing industries contributing to the nutrient enrichment of our coastal waters. The full range of impacts has not been determined, as there is a lack of data relating to Atlantic seafood processing plant effluents. Several studies were completed in the 1970s, followed by a series of reports as part of the Fraser River Action Plan (FRAP), however little has been done to assess the significance of the environmental impact of seafood processing wastes in the Atlantic Region.

Seafood processing plant effluents have the potential for generating acute and chronic toxicity problems, or more general impacts on fish habitat and marine environmental quality. In addition to sedimentary habitat problems created by organic loading, effluents could also lead to contaminant build-up in sediments (e.g. metals or persistent organochlorines) resulting in more direct toxic or chemical contamination of fish and shellfish species of commercial or recreational importance.

Wastewater from processing facilities originates from a variety of sources including fish unloading, dressing, equipment spraying, process additives, equipment disinfection and facility cleaning. Generally, fish processing facilities make use of water not only for fish cleaning, but also to flush offal and blood from equipment and floors, and to transport or

flume the offal to floor drains and collection sumps. Automated processing equipment sometimes has permanently installed water sprays to keep the equipment clean and to flush offal away. Apart from resulting in high water consumption, this method of equipment cleaning and offal transport causes the mixing of the rinse water with offal and blood. Any soluble biological oxygen demand (BOD) components (i.e. blood) will be dissolved in water. Dissolved compounds cannot be removed by physical treatment such as screening and are discharged unchanged by such treatment. Wastewater characteristics vary substantially with the type of species processed, applied processing technology and type of finished product.

Overall, high BOD and nitrogen content can be expected in effluents from seafood processing facilities. Most of the BOD and total suspended solids (TSS) originates from the butchering process and the high nitrogen content is due to high blood and protein content in the wastewater streams. Water usage, and the contact time between the water and product also have a significant effect on the effluent quality.

As well as a high BOD, TSS and nitrogen, seafood processing effluents will also contain chemicals specific to the species, process, and products being produced. These include food additives, disinfectants, cleaners, and pest control products.

Variations in daily production, water use and waste concentration values make it difficult to calculate precisely the amount of waste discharged for each unit of production. A wide range of contaminant loading per tonne of fish/shellfish indicates that loading also depends upon the species processed and applied processing technology.

Wastewater from processing facilities is generally untreated except for fine screening prior to discharge from the plant. The Fish Processing Operations and Guidelines (1975) provide guidance to fish processors on the minimum effluent control required to comply with the intent of the *Canada Fisheries Act*. The Guidelines prescribe the principal of best practical treatment technology for processing plant effluents, and include solids removal by a 25 mesh screen, a well-designed out fall discharging below low tide, the recovery of certain high strength wastes, and good housekeeping. The guideline also indicates that if discharge of treated liquid effluents leads to a deterioration of the receiving water quality, then the fish processing operation may be required to install more advanced liquid effluent treatment.

Best Management Practices (BMPs) for managing wastewater effluent from fish processing operations were completed in 1994 by Vassos et al. (Guide for Best Management Practices for Process Water Management at Fish Processing Plants in British Columbia, FRAP Report 94-20). Based on this material, a pollution prevention planning guide was completed in 1995 by the same authors.

Recognizing the limited information available, the National Program of Action Atlantic region team initiated a project to develop a better understanding of discharges from seafood processing operations. This project is ongoing, and when complete will create a foundation for the development of a management plan.

Discussion

Questions in the discussion that followed the presentation focussed on both technical and policy aspects of the information provided.

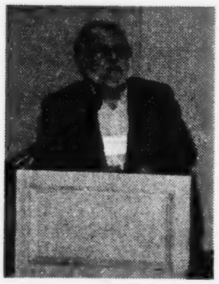
On the technical side, it was clarified that the majority of nitrogen compounds leaving fish plants operating in the processes characteristic of this region takes the form mostly of organic nitrogen (nitrates and ammonia). In addition it was noted that a good deal of the literature available on the characterisation of fish plant effluents in this region, and indeed across Canada, is out of date, representing results collected as long ago as the 1970s. For example Jeffrey Corkum quoted literature that gives numbers of around 40 mg/L BOD in crab process effluent but he clarified that the true figure would be closer to 400 mg/L since there was little crab being processed when the earlier results were generated.

Also while his report indicated there were 650 processing plants in Atlantic Canada in 2000, the figure today is more like 580 with no decline and indeed an increase in overall production and thus a potential concentration of effluent volumes. The causes underlying this concentration of processing capacity are complex, including factors such as the cod moratorium and other changes in the fishery, increased transportation of raw material to local plants from other regions and countries, etc. It is also in part related to the growth of the aquaculture industry, which also provides product to fish plants. But other than the extent to which aquaculture provides raw material to fish plants, it is not intended to focus the current study EC study on environmental effects of aquaculture.

On another matter, the study of the fish processing industry that took place in British Columbia in the mid-1990s showed significant effort in improving effluent concentration and quality but even so, tests universally continued to show unacceptable acute toxicity (LC50) results, demonstrating a continuing problem in achieving compliance under Section 36 (3) of the *Canada Fisheries Act*.

In regard to policy issues, a representative of the plant operators noted that it would be unfair and a competitive disincentive to pursue tighter regulation of the industry in New Brunswick without doing so simultaneously across the country because all fish plants operate in the same global market. Addressing the problem must involve Québec and British Columbia as well and must be a truly national initiative. In answer to a question on the duration of the NPA study being led by Environment Canada, Jeffrey noted that it is divided into phases and that Phase One, the characterisation phase drawing on existing information held by EC, the provinces, DFO and the Canadian Food Inspection Agency (CFIA) is nearly completed. Phase Two, which involves co-operation of industry in assessing various effluent streams in real time, will begin this year. Finalising the study, with the carrying out of pilot projects and recommendation of Best Management Practices (BMP) and Pollution Prevention (P2) methodologies might take two or three years depending on availability of funding and the ability to find partners in the industry.

2.2 Lamèque Bay Environmental Management Study. Scott MacKnight (OCL Group)



Biographical Sketch

With a background in chemical oceanography, Dr. Scott MacKnight has 25+ years experience in the environmental assessment and management of contaminants in the coastal and estuarine marine environment. He has conducted projects in many of the harbours and waterways in Atlantic Canada. In addition, since 1990, he has also been working on port and waterway projects in China, Indonesia and the Caribbean region.

Abstract

Scott MacKnight[1], Cynthia Gillis[1], Jochen Schroer[2], John Allen[2], Bruce Comeau[3] and Bertin Gauvin[4]

[1] OCL Services Ltd., 47 North St., Dartmouth, N.S. B2Y 1B7
[2] NATECH Environmental Services Inc., 109 Patterson Road, Harvey Station, N.B. E6K 1L9
[3] Groupe Roy Consultants, 548 King Ave., Bathurst, N.B. E2A 1P7
[4] Coalition pour la viabilité de l'environnement de Shippagan et des Îles Lamèque et Miscou. C/o Lamèque Town Hall, Lamèque, N.B. E8S 1P6

Overview

Since the mid-1980s, the citizens of Shippagan, Lamèque and surrounding areas have expressed concerns regarding the perceived environmental degradation of the adjacent marine waters. Various studies focussing on individual trouble spots have been undertaken with the objectives of identifying sources and recommending corrective actions; however, a broader study of Lamèque Bay has not been attempted and several questions were left outstanding.

With funding support from the New Brunswick Environmental Trust Fund, *La Coalition pour la viabilité de l'environnement de Shippagan et des Îles Lamèque et Miscou* (CVESLM) undertook a study in 2002 to:

- Provide an explanation for the odour problem along the beach of Lamèque and discuss potential remedial solutions;
- Assess whether there is an interaction between the effluent discharges from Lamèque and Shippagan;
- Determine alternatives for managing the environmental health of Shippagan and Lamèque Bay;
- Provide recommendations for action.

Study objectives

From these broad goals, a set of study objectives and work activities were developed:

(1) Physical Circulation and Flushing. One of the reasons for an accumulation of wastes and thus odours in the northeastern (head) end of Lamèque Bay could be inadequate circulation and flushing of Lamèque Bay. Also circulation patterns may result in undiluted or partially diluted wastes from Shippagan being transported to the inner sections of Lamèque Bay. Other circulation-related issues would include dispersion of other effluents.

A physical circulation model will be developed and tested. The outcome will be a description of a general circulation model for Lamèque Bay and its interaction with waters passing through Shippagan Channel.

(2) Effects. The existing effluents from Lamèque Co-op have elevated concentrations of total phosphorus. Could these effluents, if not being adequately dispersed, result in eutrophication of local waters? Are there other sources of nutrients contributing to the overall water quality of Lamèque Bay? Could wastes from Shippagan not be fully diluted and also contribute to the nutrient loading of the upper Lamèque Bay?

An evaluation of the effluents and other possible sources of nutrients that promote the growth of marine plants will be conducted. This will include assessment of water quality and an evaluation of marine plant growth and deposition and/or accumulation.

(3) Odours. The issue of odour appears to be correlated with the accumulation of very large amounts of sea lettuce (*Ulva lactuca*) along the inter-tidal area and shoreline of the front of the Town of Lamèque. Is the fish processing plant effluent the only source of nutrients and organic matter to initiate and promote the growth of this marine plant? What role do nutrients and wastes from other sources play?

An evaluation of sea lettuce as a problem source will be conducted. The assessment will include an evaluation and placing in context of all sources of nutrients.

(4) Remediation. If the primary environmental issue is inadequate dispersion of overly nutrient-rich fish processing plant effluents combined with more other nutrient sources, all resulting in excessive growth of sea lettuce, how can the problem be resolved? Also if the issue has been on going for several years, has there been an accumulation of nutrients within the sediments that can act as a 'reservoir' for nutrients for several years after primary effluent sources are treated?

Several scenarios will be tested using the total phosphorus distribution and variation model: (a) change in the location of the outfall; (b) use of a diffuser to further disperse nutrients from the effluent; (c) use of various treatment processes to address the nutrient loading of the effluent; and (d) dredging to remove accumulated nutrient-rich sediments.

Conclusions

From the site work conducted in July and August 2002, the following conclusions were developed to address several key questions:

1. Do the effluents from the Shippagan fish plant operations and other sources impact on the water quality of Lamèque Bay?

The discharges of Shippagan and Lamèque are too far apart to influence each other.

2. What is the influence of nutrient loading from the Lamèque sewage treatment facility?

The town sewage treatment facility increases nutrient loading to Lamèque Bay because it does not have tertiary treatment. Currently, the associated environmental effect is limited to negligible, compared to the nutrient loading due to the Lamèque Co-op effluent.

3. What is the influence of aquaculture operations on the nutrient budget of Lamèque Bay?

The effects of the mussel farms on sea lettuce growth are not known. It is suggested that the physical presence of the mussel farms may attenuate the natural flushing and cleaning actions on the intertidal zone at the centre town waterfront. Further, while the mussels within the leases will filter feed from the water column, they also excrete nutrients and therefore can be considered a nutrient source.

This study identified a significant requirement for a mathematical model that can better predict impacts of shellfish aquaculture operations on the surrounding environment, in terms of both impact on physical processes and contributions to nutrients in the water column and sediments.

4. Is there sufficient assimilative capacity within Lamèque Bay to accommodate the existing effluent from the Lamèque Co-op facility?

The simple answer is no. The current outfall is located at the shoreline. Much of the effluent has limited dispersion in the general area of the outfall, without sufficient dilution to "background" concentrations of nutrients. Further, the nutrient loading of the current effluent is very high and variable, based on the scope and nature of the process being used (shrimp, crab, groundfish). The issue of limited dispersion is exacerbated by the nutrient loadings. The impact of the nutrient loadings on the receiving environment is also multiplied by the nature of the effluent with a combination of dissolved aqueous liquid phase that readily mixes with the receiving waters; an oil & grease liquid phase that does not readily mix with the receiving waters, but can transport nutrients to other areas; and a solid phase of organic materials, rich in nutrients and readily transported to the sediments in the general area of the outfall.

The computer model results of this study highlight the assimilative capacity problem. Simple placement of the existing effluent outfall to another location further into Lamèque Bay will not provide sufficient nutrient dilution. Even the addition of a diffuser to further promote dilution will not provide sufficient remediation of the problem. The effluent requires both a reduction in nutrient loading at source (i.e. treatment before discharge) and better placement of the outfall location to achieve dilution. These recommended improvements would only address future loadings of nutrients to the Bay; they will not address the reservoir of nutrients that has established over the years within the Bay sediments near the town's waterfront.

As noted earlier, a considerable portion of the nutrient loading from the Lamèque Co-op effluent enters the receiving system associated with an oils and greases phase and a solid phase. It is suggested that much of the nutrient loading from these two phases has entered the sediments to form a "reservoir" to promote future plant growth. To address the problem of near-eutrophication in the inner Bay will require both reduction of nutrient loadings from all sources and removal of the nutrient reservoir.

5. How does the nutrient loading impact the environmental quality of Lamèque Bay?

In most marine areas, concentrations of either phosphorus or nitrogen compounds are low and become "limiting nutrients" to the growth of marine plants. In Lamèque Bay, there is a combination of three aspects, which provide for excellent growth conditions of the sea lettuce:

1. nutrient-rich discharges;
2. appropriate growing conditions (i.e. quiescent waters, sufficient sunshine and shallow water depth combining to permit warming of water); and
3. accumulation of nutrients in the near-waterfront sediments providing a large potential reservoir of nutrients.

The existing nutrient loading attributed to effluents could be reduced, through control at source and/or improved dispersion/dilution. Nutrients have entered the sediments through a combination of routes: (1) during its growth cycle, sea lettuce takes up large amounts of nutrients which become associated with the sediments upon death and decomposition of the plants; (2) large quantities of nutrient-rich oil and grease and other suspended solids discharged by the Lamèque Co-op effluent are deposited in the sediments. This source can only be addressed through removal by dredging and disposing to an approved disposal site.

The spreading of sea lettuce threatens the Lamèque Bay ecosystem. Decomposition of sea lettuce in the sediments is incomplete and leads to anoxic sediments that exclude most benthos. Further, the release of hydrogen sulphide from the sediments also impacts the near-bottom water quality and excludes bottom-feeding fish. The sea lettuce beds may overwhelm the eel grass beds, which provide significantly better fish habitat. To limit and reduce this environmental problem requires implementation of a rigorous nutrient management plan.

6. What about the odour problem?

Inspection of the intertidal zone along the centre of the Lamèque waterfront showed an accumulation of three odour-producing aspects:

1. Accumulation of large quantities of sea lettuce fronds. Material is stranded on the intertidal zone due to a falling tide and accumulated in large amounts in adjacent waters.
2. Presence of another green seaweed, as extensive growths on the rocks, hard-pan and cobble of the intertidal zone from approximately the mid-point of the intertidal zone westward to the graveyard near Portuaire de Lamèque.
3. Deposition of suspended solids and oils and greases associated with the fish plant effluent during periods of rising tide.

The summation of these three aspects is an accumulation of organic-rich materials in large quantities, such that rapid decomposition and complete recycling within the ecosystem is not possible. Underlying sediments and the accumulated materials become anoxic and readily release volatile sulphides. The process is further enhanced during summer when temperature and sunlight conditions on the exposed intertidal zone make growing conditions optimal.

To address the odour issue will require addressing all processes that contribute to sea lettuce and sea fern growth or otherwise create beneficial growing conditions.

7. What effect does the (ruisseau Charlemagne) causeway have on the odour problem?

There are two areas where the odour problem is very intense: the waterfront near the fishing port facilities and salt marsh at the Lamèque end of the ruisseau Charlemagne causeway. It is unlikely that the causeway has an effect on the accumulation of sea lettuce at the water front; it is concluded to have a direct effect on the accumulation of sea lettuce in the salt marsh. The entrance of the channel is like a funnel created by the causeway and sand bar forming the marsh. When the tide rises, suspended material circulating along the shore is deposited in the marsh. During falling tides, sea lettuce is trapped and accumulates within the pools and channels of the marsh. At low tide, decomposing material releases strong sulphide odours. The odour issue is a major nuisance to surrounding businesses and residents. Relocating the fish plant outfall and/or reducing the effluent strength will likely address this issue. If there are residual problems with odour in this area, conversion of the marsh to an engineered wetland with better control over water movement (with associated sea lettuce) in and around the marsh is recommended.

Recommendations

Implementation of any recommendations will take time:

(1) to permit proper siting and design studies for the Lamèque Co-op outfall and the potential concurrent re-siting of the shellfish aquaculture facilities;
(2) to obtain permits and approvals to dredge the nutrient-rich sediments from the inner Bay area, with disposal in the confined facility to the west of the fishing port.
(3) to obtain permits and approvals for the marine civil works and the re-positioning of the aquaculture leases (e.g. *Navigable Waters Protection Act (NWPA)* Permit, Habitat Alteration authorisation, Ocean Disposal Permit, *Canadian Environmental Assessment Act (CEAA)* Screening, etc.);
(4) to construct and commission the civil works.

1. Relocate the Lamèque Co-op outfall to a location with much greater physical dispersion of effluents.

An effluent plume delineation study should be undertaken to evaluate the resulting plume and its interaction with existing resource users. Modelling can also be applied to optimize the outfall locations and configuration. Relocation may also require shifting of the Canadian Shellfish Sanitation Programme (CSSP) shellfish prohibition zone or establishing a new zone, which could affect the existing mussel aquaculture leases.

2. Install a diffuser on the effluent outfall.

The costs of re-location of the effluent outfall could be reduced through use of a diffuser. The plume modelling study identified in recommendation #1 should also consider diffuser requirements. The design of the outfall pipe and diffuser has to incorporate the necessary cleaning velocities, nozzle exit velocities and hydraulic pressure requirements under the expected range of flow conditions.

3. Pre-treat the Lamèque Co-op effluents.

Simple relocation of the effluent outfall and the use of a diffuser may not achieve sufficient reduction in nutrient loading to meet current water quality requirements. It is recommended that the effluent be fully characterized under various loading conditions (e.g. shrimp processing, crab processing) and then an appropriate pre-treatment process be designed and implemented to provide an appropriate reduction in loadings of phosphorus, ammonia and other nitrogen-containing compounds.

4. Address the issue of residual nutrients in the Bay sediments.

Two solutions are proposed, recognizing that while improved treatment/dispersion of the nutrient-rich effluents will address future discharges, the existing reservoir of nutrients in the sediments will also have to be addressed to reduce the sea lettuce growth and associated odour problem.

(A) Harvest the sea lettuce before it breaks off and accumulates on the shoreline. Sea lettuce can be used for a number of purposes, including food, animal food and compost/fertilizer. A strategy to harvest the sea lettuce needs to be devised.

(B) Remove the nutrient reservoir by dredging the zone of nutrient-rich sediments along the front of the town. To properly assess the environmental impact of such an operation and to better quantify the costs and effort will require a better definition of the areal extent and depth of nutrient-rich sediments, or at least those impacted by sea lettuce, as defined by elevated concentrations of sulphide in the sediments. This provides a more permanent solution than option (A), but is more costly and will disrupt the existing environment.

5. Improve the saltwater marsh at the Lamèque end of the ruisseau Charlemagne causeway.

The present saltmarsh is very limited in scope, but is a serious impediment to use of the waterfront due to the accumulation and decomposition of sea lettuce and other algal growth. The layout and channelisation provide a configuration that optimizes trapping of sea lettuce and other algae during high tides and storm excursions. The saltmarsh could be re-engineered to provide an attractive area that is configured to not trap sea lettuce nor provide a focal point for algae growth.

6. Develop a Lamèque Bay Environmental Management Strategy and Plan.

As with many other Atlantic Canada communities, the environmental quality of the adjacent marine waters only becomes an issue when conditions have become so degraded as to create aesthetic and odour problems. While each land-based source of pollution may not be considered significant, or even worthy of notice as an impact to the marine receiving environment, the cumulative effect of all sources is often critical. This situation has arisen because most marine receiving systems are not viewed as one system, but rather each source is considered separately. The formation of a stakeholder group, *Coalition pour la viabilité de l'environnement de Shippagan et des Îles Lamèque et Miscou*, opens the opportunity to develop and implement a Lamèque Bay Environmental Management Strategy and Plan. These would include: (a) a statement of the environmental quality of the Lamèque Bay desired by the town and its citizens; (b) a set of objectives and targets with appropriate dates of achievement; e.g. elimination of the sea lettuce problem by 2005; (c) a definition of conditions to be met by future effluents and other land-based sources to Lamèque Bay and (d) a system for continued monitoring of Lamèque Bay (water and sediment quality) to ensure the objectives and targets are being met, with suitable presentation of the information to the community.

Discussion

A question was asked as to what level of pre-treatment of effluents they were proposing before discharging the wastes through the relocated outfall? In general 25 and 50 % of the Phosphorus (P) and about the same percentage of the Nitrogen (N) would need to be reduced. In follow up to this answer another participant wondered why so much emphasis was being placed on P and not N? Is it the limiting factor? Scott responded that neither is the limiting factor here because both are present as a surplus. Ordinarily N is the limiting factor in marine plant production.

A concern was raised about chemicals used in the fish plant for cleaning. The presentation seemed to focus solely on organic contaminants. Scott agreed that nowadays many cleaners are used in the fish processing line but still contended that BOD and nutrients are the major problem. The questioner agreed but noted that it is important to identify the high level of these numbers compared to the municipal effluent, as has already been alluded to in Jeffrey Corkum's presentation. Scott noted how variable the figures for fish plant effluents can be over a given day and from day to day. But also he pointed out that municipal effluents can be a considerable contributor.

It was argued by one participant that capping the sediments isn't a solution here because of the current shallowness of the area and the fact that the sediments would be disturbed or the new bottom contour could constitute a hazard to shipping. Scott noted that he was just presenting the alternatives for the community to consider and was not attempting to identify the pros and cons, but dredging does seem a better alternative in this case.

Finally the Chairman noted that these first two presentations have demonstrated a clear challenge across the whole industry. This industry is a major economic mainstay in the region and we must find solutions that will work within the economic realities.

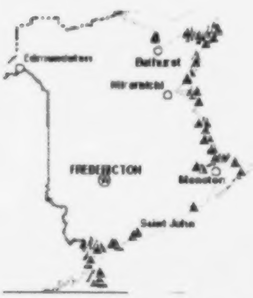
2.3 An industry perspective. Angélina Cool (N.B. Seafood Processors Association)

Biographical Sketch

Angélina Cool is the Executive Director of the New Brunswick Seafood Producers Association. Before coming to her current position in 2002, Angélina had been in business and had also been working with the seafood processing industry.

Abstract

The New Brunswick Seafood Processors Association represents many, though not all of the seafood processors in the Province. However, because of the large number of plants they represent and the wide geographic range of those fish plants, the province considers that they represent the industry as a whole when consulting or seeking advice on issues affecting the industry.



In New Brunswick, fish processing takes place in 148 facilities along the coast. These are mainly located on either the southern Gulf of St. Lawrence or in the Bay of Fundy. While these plants are widely dispersed along the coast there are areas of major concentration such as the Acadian Peninsula and the Shediac/Cap-Pelé area and the Fundy coast. In Cap-Pelé/Shediac, lobster is the major fish product, while snow crab is the main product in the Acadian peninsula area and sardines and farmed salmon are mainly processed in the Fundy and Grand Manan area. In total, there are 37 species being processed in New Brunswick, with over 200 different processing methods (20 methods of processing for herring alone, for example). In addition, there are a number of plants that specialise in fish meal production. In total, over 12,000 people are employed in the primary and secondary processing sectors of the industry.

The following is a compilation of all fish species processed, the number of processing methods and the number of plants processing each species.

Species Processed	Processing Methods	Number of Plants
Haddock	4	6
Alewife	4	27
Dulse	1	3
Shad	2	3
Eel	5	5
Periwinkle	3	8
Capelin	1	3
Clam	3	14
Crab	8	11
Snow Crab	9	21
Jonah Crab	2	1
Shrimp	6	8
Smelt	4	12
Flounder	4	11
Halibut	4	6
Gaspareau	4	4
Pollock	5	9
Herring	20	47
Lobster	13	46
Oyster	2	12
Surf Clam	4	6
Mackerel	13	26
Hake	10	14
Cod	9	24
Mussel	3	7
Sea Urchin	3	5
Quahaug	2	8
Scallop	3	24
Plaice	3	9
Skate	1	2
Shark	2	9
Sardine	1	1
Salmon	3	23
Red Fish	2	4
Sole	2	11
Rainbow Trout	2	6
Turbot	2	6
Sub-Totals	**169**	**442**

Other Seafoods		
Sea Lettuce	1	1
Laminaria digitata flake	1	1
Sub-Total	**2**	**2**
Farm Raised Fish		
Atlantic Salmon	11	20
Brook Trout	10	6
Steelhead	2	1
Rainbow Trout	2	1
Sub-Total	**25**	**28**
Derived Products		
Crab fish meal	1	3
Fish meal	1	2
Herring fish meal	1	2
Lobster fish meal	1	2
Fish oil	1	3
Sub-Total	**5**	**12**
Total Processing Methods	**201**	**484**

This wide diversity of processes and products is paralleled by high diversity in the markets to which these products are shipped, in the Americas, Asia, Europe and the Caribbean for the most part. Annually, over 90,000 tonnes of fish products are exported from New Brunswick, constituting the vast proportion of local production. While the US market is clearly dominant, with 71 processors shipping to this market, Japan is also a major trading partner with 30 processors shipping there.

This dependence on international markets must be borne in mind when considering strengthening environmental controls on the industry. The New Brunswick industry is anxious to see improvements be made, but not in isolation; it is part of the same industry as fish plants in other provinces and cannot be expected to remain competitive if subjected to different rules than these other jurisdictions. It is important to remember that the industry is not self-regulating but follows standards set by DFO, EC and the province.

Discussion

During follow up discussions, Angélina noted that Connors Brothers in Blacks Harbour is the single largest fish plant currently operating in the province. Though statistics are not currently available, it is likely that the Co-operative des Pêcheurs de l'Île in Lamèque may be the second largest. It was noted that, though these two plants may be similar in size and production quantities (though not in products processed), the environmental conditions in which they find themselves (the highly dynamic and active Bay of Fundy versus the small enclosed Bay of Lamèque) result in entirely different environmental consequences and dictate the need for differing environmental control strategies and standards.

It was also noted that the N.B. Seafood Processors Association is affiliated with the Fisheries Council of Canada, which represents fish processors from across the country, and it was agreed that any effort to involve the industry at the national level to bring about improvements in environmental safeguards should involve the Council.

2.4 Regulatory context: How are fish plants regulated now? Perry Haines (N.B. Department of Environment and Local Government)

Biographical Sketch

Mr. Haines has been with the New Brunswick Department of the Environment and Local Government (DELG) for more than 16 years. He is currently the Director of the Approvals Branch for the Department. It is the Approvals Branch that issues the Approval to Operate for fish processing plants in New Brunswick. Perry has a Bachelor of Science in Engineering and a Master of Science in Engineering, both from the University of New Brunswick in Fredericton. Prior to working for the province, Perry worked for Imperial Oil in Toronto.

Abstract

Each fish processing facility that discharges processing effluent directly to the receiving waters requires a Water Quality Approval to Operate under the *Water Quality Regulation – Clean Environment Act*. The facility is placed in either a class 1A, 1B, 2, 3 or 4 depending on the worse case scenario of volume of effluent discharged, Biochemical Oxygen Demand (BOD), or Total Suspended Solid (TSS). The Water Quality Approval to Operate contains standard conditions that are taken from the Federal "Fish Processing Operations Liquid Effluent Guidelines" document of June 1975. These generic conditions require screening of the effluent to remove solids and submerged outfalls to enhance flushing. Other conditions can be included in the Approval at the discretion of the Department such as log book and alarm requirements. Beginning in the fall of 2002, the New Brunswick Department of Environment and Local Government (DELG) began requiring all class 1, 2, and 3 processing plants to carry out sampling and testing of their processing effluent as each plant's approval is renewed. This information will aid DELG in carrying out correct classifications of plants as well as the ability to monitor those having high contaminant loadings.

Due to the increased attention received by fish plants over the past years, DELG has initiated conversations with Environment Canada (EC) with the goal of having the Federal Guidelines revised. This action would be a consistent approach across Atlantic Canada and therefore maintain a level playing field amongst fish plants competing in the same market in each province. Until the goal is achieved, DELG will continue to inspect fish processing and meal plants to ensure compliance with their Approvals to Operate.

Discussion

It was noted that aquaculture is under more regulatory scrutiny these days and wondered if the same were true of new fish plants. Is this more rigorous now? Perry noted that what has changed is that a new fish plant applying for an operating license today could trigger an environmental assessment (EA) provincially, which is a much more rigorous form of review than in the past.

On a technical matter, the question was posed about how many plants use and therefore discharge fresh versus salt water. Unfortunately this information is not available, but should form an important part of any survey of the industry since it will affect both control measures and immediate impact in the environment.

Another participant wondered if the plant owners or operators know when the province conducts its sampling and if that would that affect the results. Perry noted that they don't generally know when the inspectors are coming and results from routine inspections are therefore verified.

The question arose if other Provinces have the same approach to control with similar categories of operation and inspection requirements as described. While Perry was not familiar with other provinces' approaches, a colleague present from DELG, Danny Stymiest, responded that he knew of other provinces that don't regulate fish plants at all.

Another question dealt with whether the reporting and testing was done by the plants themselves or analysed by an impartial body. Perry acknowledged that it is the company's responsibility to do routine testing, but the Province does its own spot checks. It was also noted and agreed that composite samples would be a preferable methodology than single grab samples and that the current sampling regime is only a start and will be improved over time.

Perry was asked at what point DELG takes action, in other words, what is the trigger for a prosecution? Perry noted that they look at the results and turn it over to the Enforcement group in DELG to make a legal determination of the course of action required.

A participant wondered if DELG would be hoping for treatment rather than just screening requirements in a revised set of federal guidelines or regulations if these were to be developed? Perry agreed that this should be looked at if that is the route taken to provide improvements in the industry but also noted that this is not what his workshop was assembled to consider. He reiterated the need for national action if there are to be upgraded guidelines down the road.

It was observed that the provincial classification system doesn't include dissolved nutrients as a parameter to be measured. This seems a serious omission. Will the Province be looking into this in future? Perry noted that the classification system applies to many different industries, not just fish plants, and therefore has to be somewhat generic. There is currently no plan to have a separate classification system for fish plants.

Another participant wondered when there is a problem at a fish plant does the Province collaborate with EC on enforcement? Perry noted there is a dialogue, of course, but each organisation goes its own way in enforcement matters in view of their respective regulatory mandates and legislation.

In a specific challenge, one person asked if Perry thought it is logical that in 2003 fish plants are polluting the environment the way it is now happening in Lamèque? In 2000 the provincial staff in Bathurst said that they were too overworked to be able to focus on the Lamèque problem. Will they increase the staff assigned? In responding to the latter question, Perry noted that like any other government organisation they do prioritise because there is never enough staff to go around and Bathurst is probably no more poorly equipped to deal with the work than anywhere else. On the general subject of the problem in Lamèque he said that the province is concerned about this and working hard to find solutions, but the purpose of this workshop is to look at the whole problem across the industry and the region not one specific problem, no matter how severe. The workshop was a combined approach to problem solving in which the Department of Environment and Local Government has collaborated with the provincial Department of Agriculture, Fisheries and Aquaculture, EC and DFO.

Another participant raised again the need for a flexible regional approach. It is difficult to deal with the problem generically because there are plants in active environments where their wastes are harmless and even others which are still dumping their solid wastes at sea. Perry agreed.

2.5 Ecological impacts of nutrient loading in coastal ecosystems.

Inka Milewski (N.B. Conservation Council)

Biographical Sketch

Inka is a marine biologist with 25 years of experience working at local, provincial, national and international levels. She has worked with government agencies, universities and non-profit research, conservation and community organizations including the Huntsman Marine Science Centre, Science Council of Canada, World Wildlife Fund and the Conservation Council of New Brunswick. Her work in marine conservation and education have earned her international and local recognition. She is the author and co-author of several peer-reviewed and popular science publications such as *After the Gold Rush, The Status and Future of Salmon Aquaculture in New Brunswick, Shifting Sands: State of the Coast in Northern and Eastern New Brunswick*, and more recently *Two hundred years of ecosystem and food web changes in the Quoddy Region, Outer Bay of Fundy* and *Oysters in New Brunswick: more than a harvestable resource*. She is currently Marine Science Advisor for the Conservation Council of New Brunswick.

Abstract

Heike K. Lotze[1], Inka Milewski[2‡], Boris Worm[1] and Zsofi Koller[2]

[1] Biology Department, Dalhousie University, Halifax, Nova Scotia, B3H 3J5
[2] Conservation Council of New Brunswick, 180 St. John St., Fredericton, New Brunswick, E3B 4A9
‡ Contact Information: Inka Milewski, Marine Science Advisor, Conservation Council of New Brunswick, 254 Douglasfield Road, Miramichi, New Brunswick, E1N 4S5, Canada, e-mail: milewski@nbnet.nb.ca; tel. (506) 622-2460

The Conservation Council of New Brunswick (CCNB) conducted a field survey on the sources and symptoms of nutrient pollution (or eutrophication) in eelgrass beds and its associated flora and fauna in July 2002. Initially, the aim of the study was to comparatively investigate 5 high- and 5 low-impacted estuaries and coastal bays along the coastline of eastern New Brunswick. The high-impacted sites were Bouctouche Bay, Cocagne Bay, Baie Sainte-Anne, Lamèque Bay and Jacquet River estuary. These would be paired, for comparison purposes, with low-impacted estuaries and bays in the same geographic vicinity. For example, Bouctouche and Cocagne would be compared with the two estuaries in Kouchibouguac National Park - the Kouchibouguac and Kouchibouguacis. Baie Sainte-Anne would be paired with Tabusintac as a low-impacted bay and Jacquet River estuary would be paired with Charlo River estuary. As it turned out, the Charlo River estuary was an impacted site.

In search of a less impacted control site in the vicinity of Lamèque Bay, we visited Petite Lamèque Bay, Miscou Harbour and Baie Saint-Simon-Sud. All these bays looked very similar to Lamèque Bay - drifting dead eelgrass in the shallow water, large patches of drifting and decomposing annual green and brown algae, anoxic zones, bacterial mats and hydrogen sulphide odours. A decision was made that quantitative analyses would be done on four impacted estuaries (Bouctouche, Cocagne, Baie Sainte-Anne, and Lamèque) and the only three low-impacted estuaries we could locate - Kouchibouguac, Kouchibouguacis and Tabusintac. The remaining sites (Baie Saint-Simon-Sud, Jacquet River and Charlo River) would be assessed only qualitatively.

At each sampling site a range of variables were measured including: (1) the structure of eelgrass beds (shoot density, canopy height, total cover); (2) the abundance and diversity of annual algae (epiphytes, free-floating and bottom-growing macroalgae); (3) the abundance and diversity of associated animals (filter feeder, epiphytic animals, herbivores, detritivores, predators); (4) the abundance of phytoplankton in the water column (Chlorophyll *a* concentration); and (5) water characteristics (temperature, salinity).

Both, low- and high-impacted sites showed similar eelgrass bed structure (shoot density, canopy height), but at high-impacted sites the meadows were more patchy and not as homogeneous as at low-impacted sites resulting in overall lower eelgrass cover. High-

impacted sites showed two-fold increases in epiphyte load, bottom-growing or drifting algae, and phytoplankton concentration compared with low-impacted sites. These high epiphyte and phytoplankton loads increase light limitation on eelgrass likely reducing eelgrass productivity, because eelgrass is dependent on high water clarity. Annual drifting or bottom-growing algae have a short life span and decompose during summer and fall. High loads of decomposing annual algae contribute to low-oxygen or anoxic conditions, which have negative effects on eelgrass health and survival. During the survey, all high-impacted sites showed signs of anoxic conditions and resulting emissions of toxic hydrogen sulphide.

The fauna associated with eelgrass beds also showed clear differences between low- and high-impacted sites. Although high-impacted sites had similar filter feeder abundances, the number of detritivores was 6 times higher, the number of herbivores was 3 times lower, and the number of predators was 10 times lower compared to low-impacted sites. These differences in the animal community show a clear shift from a herbivorous to a detritivorous food chain that utilizes the overabundance of decomposing organic matter. Species richness and diversity of the entire community did not differ between low- and high-impacted sites. However, there were severe shifts in the species composition within the community. At sites with high nutrient loading, red algae and epiphytic animals were replaced by green and brown algae, and herbivores were replaced by detritivores.

The results from our field survey indicate clear signs of eutrophication with strong shifts in the plant and animal communities between sites of low- and high-nutrient loading. Such shifts in community structure can alter the functioning of the community in the ecosystem. Thus, eelgrass meadows in high-nutrient environments may not perform their natural role and ecological importance as well as they do in low-nutrient environments. But, their role as a filter and buffer in the nutrient cycling of the oceans, as a nursery and spawning ground for commercially important fish and invertebrates, as a sediment stabilizer, and as habitat for a high diversity marine flora and fauna are important ecosystem services that contribute to the well-being of coastal ecosystems and human society.

Based on the survey results, the Conservation Council recommends that mitigation efforts should concentrate on the reduction of point and non-point nutrient loading. Sewage treatment plants and control of municipal, commercial and industrial discharges can reduce nutrient loading through point sources, while restoration of wetlands along the coastline and around agriculture operations can serve as a natural filter and buffer between land and sea, which store and recycle nutrients thereby reducing non-point nutrient loading.

Discussion

One participant noted that global warming is an issue in the observed eutrophication in coastal areas and estuaries in New Brunswick as well as nutrient enrichment from land-based sources. How can one discern which is the more dominant controlling factor in phenomena like the occurrence of harmful algal blooms (HAB) for example? Inka responded that Steven Bates (DFO researcher) has investigated this and has concluded that the controlling factor is nutrients. Temperature rise alone is not enough.

Thierry Chopin, who spoke later on the agenda on this subject, added that "green tides" are indeed set off by high nutrient loading but this really does need settled conditions too. Observers don't see this phenomenon in Norway despite high nutrient enrichment because the small tidal amplitude reduces the intertidal zone and nutrients settle in deep water. Inka added that aquaculture needs to be controlled at the fish farm level. Each farm can contribute as much as 40 to 60 metric tonnes of organic nitrogen a year.

Another observer posed the question, if things don't change, what does the future hold for N.B.? The reply was that if we don't deal with the problem, these estuaries will become mud holes with few predators and no fisheries. Water quality will be impacted to the extent that swimming will not be possible. So we need to put a stop to nutrient enrichment from all sources like septic systems in Bouctouche and fish plants in Lamèque for example.

Inka was asked to comment on what she thought about shellfish culture on the east coast of N.B. and how it related to this discussion. She responded that it can contribute to nutrient load in a particular bay but it depends on the state of the bay if this is significant or not. There are limits to how much shellfish aquaculture an area can support without becoming eutrophic. Growers should be very concerned about nutrient pollution they are causing because of the link between eutrophication and toxic algal blooms that could jeopardise their own operations.

Another observer wondered about putting back the nutrients we are taking out through fishing. Isn't this a good thing? Inka explained that in these embayments the input far exceeds anything we take out. Fish wastes represent input from a vastly larger area than that being impacted. We need to manage by scale. Globally, experts agree that we are already putting far more nutrients into the oceans than we are taking out.

The question was posed if the situation at Lamèque seen last year, where it was necessary to shut down shellfish harvesting for several weeks, is going to repeat itself and if it is possible that harmful algal blooms will occur there? Nothing has changed to prevent that situation from happening again. The problem can only get worse and the possibility of HAB incidents occurring cannot be discounted.

Another person asked if Inka would say it is too late to make a change for the better in Lamèque. She responded by noting an observation by her co-author, Heike Lotze. Even a vastly larger problem area like the Baltic is recovering from serious nutrient overloading after concerted action for 30 years. We need to give local problems like that in Lamèque the same chance to recover.

3.0 FINDING SOLUTIONS

What can be done to reduce environmental impacts?

The second session of the workshop dealt with the wide-range of potential solutions suggested by industry, academics, technologists and scientists. Their presentations were examined under the overall framework of the workshop, that is, in-plant solutions, end-of-pipe solutions and receiving environment applications. The third heading also briefly examined other potential options including by-products and other value added opportunities.

As in the case of the previous section, each presentation below includes a brief biological sketch of the speaker, an abstract of their presentation and a summary of the question and answer period that followed their presentation. However in this section, at the completion of the presentation on each sub-theme, a panel discussion also took place. A synopsis of these discussions is presented with comments generally not attributed except where an interesting statement emerged that seemed to capture the essence of the discussions. These have been attributed with the agreement of the speaker in question.

Sub-theme A: In-plant modifications & material recovery

Chair: Sylvain Poirier

3.1 Maximizing return from seafood processing waste and effluent management. Andy Woyewoda (National Research Council - Industrial Research Assistance Programme, Halifax, N.S.)

Biographical Sketch

Education:

BSc (Hons) Chemistry - University of Alberta, Edmonton
MSc Food Science – University of British Columbia, Vancouver

Experience:

- 3 years DFO Chemist Halifax working on fats and oils, rancidity prevention, developing lab methods for measuring fish and seafood quality
- 8 years Canadian Institute for Fisheries Technology (CIFT), Department of Food Science and Technology, Dalhousie University (TUNS, Daltech) in Halifax leading research projects under contracts to seafood companies for exploring quality improvement in fish and seafood, packaging, shelf life extension. Dealt with quality of almost every commercial species including squid. Worked with modified atmosphere packaging, researched silage production, hydrolysate production, by-products opportunities, etc.
- 5 years Technology Transfer Officer for Canadian Institute of Fisheries Technology covering Atlantic Canada to link that group to industry.
- With National Research Council Industrial Research Assistance Program (IRAP) as Industrial Technology Advisor (ITA) since 1992 working with Industry in the Maritime Region in the food, seafood, aquaculture and biotech (nutraceutical) sectors to resolve technical problems and help commercialize new technological ideas and concepts.

Also serves as a resource in those sectors across Canada. Employed by the National Research Council but physically located at Department of Food Science & Canadian Institute of Fisheries Technology, Halifax, N.S.

- Has a number of publications and one patent.

Abstract

Maximizing value in seafood processing should involve (1) improving overall efficiency of processing by optimizing plant layout and achieving maximum product yield; (2) producing new value-added products; (3) using discarded material for new products; (4) recovering solids from effluent; and (5) preventing the loss of seafood protein down the drain. Improvement of efficiency should be a daily exercise and ideas for value-added products are numerous. Certain discards can sometimes be segregated for specialty / niche product markets, e.g. fish heads and stomachs for Asian markets, etc. Hydrolysate technology can be applied to solid waste to recover protein, commercially valuable enzymes may be isolated from raw viscera and crab backs, and nutraceuticals such as chitosan and glucosamine can be produced from shrimp and crab shells. Hydrolysis by an acid or enzyme process (e.g. as developed by Marine Resource Recovery from Vancouver) will yield flavours, high quality readily digestible protein for aquaculture and animal feed applications, and liquid fertilizer.

Before a firm proceeds to adopt new product concepts it must review the economics, the market and it must understand the competition in terms of other firms in production and alternate less expensive technologies under development. Raw material supply in terms of quantity, quality and consistency of those two parameters are issues that will determine product options, e.g. whether high value food grade products can be produced vs. lower value feed and bait alternatives. New product introduction may also require new infrastructure such as new expertise, more time from management, new market support and extra lab support, all of which are considerations for proceeding down this path.

The 2nd International Seafood By-product Conference (November 2002) held in Anchorage, Alaska highlighted opportunities for marine protein, especially in aquaculture, which has doubled in world production since 1990. China produces 71% of the world aquaculture supply. By 2010 fish meal requirements for feed will increase by 0.8 MT but supply may in fact be reduced by 1.5 MT from the impact of El Nino. Replacement of meal by soy and canola protein will fill part of the gap but a marine protein supplement is necessary to complete nutritional and flavour attributes. However marine proteins will have to be standardized in terms of composition and functionality.

Seafood effluent contains marine protein in the form of meat particles and free protein (from insoluble to dissolved forms) as well as fat, bone and shell fragments, and cleaning agents. Even though effluents have high total suspended solids (TSS), in practical terms these particles can only be captured by screens at levels up to 30% since the particles are soft and malleable. TSS represents the non-dissolved portion that contributes to biological oxygen demand (BOD) and is defined as material that can be captured on a 1.2 μ filter. The dissolved portion cannot be removed by screening without some type of pre-treatment to render it insoluble. BOD loading of the various streams within seafood plants varies widely. At the plant exit the high-load streams are diluted by low-load streams resulting in a stream that is difficult to treat because of high volume and dilution

of BOD. Only if high load streams were segregated would treatment be practical and effective.

Data is presented showing the effect of pH on raw crab and cooked crab solubility. At normal processing pH of 6 or 7, 95% of a raw crab blend will pass through a 10 μ filter compared to 60% of a cooked crab blend, demonstrating the high solubility of both raw and cooked crab. Between pH 4 and 5.5, 55% and 0% of raw and cooked crab, pass through respectively showing the reduction of solubility with a drop of pH. The 10 μ filter applied to effluents from raw and cooked crab processing effluent adjusted to pH 4 to 5.5 resulted in recovery of 35% and 90%, respectively demonstrating that a high portion of protein from cooked crab effluent could be recovered using pH adjustment. The data also proves that alkaline (high pH) cleaners and sanitizers will readily dissolve and release any material lodged on screens at the plant effluent exit.

Given the high solubility of seafood, the first step every plant should consider is reducing product loss to the drain by examining its entire process strategy. This will reduce BOD of effluent, product solubilisation and shrinkage, with potential for increased saleable weight. Strategies include minimizing product / water contact by reducing fluming and water cooling of product, examining all processing steps requiring water, preventing product from falling on the floor and implementing a dry clean-up by removing any from the floor prior to water flushing. Reduction of water volume can be achieved by increasing employee awareness to conserve water, using low flow nozzles, dry pre-clean up and re-use of low load water streams. These steps will reduce product loss and reduce effluent load and volume. Expensive end of pipe treatments should be applied only after these in-plant strategies have been implemented.

Ecological pressures are present to encourage all industries to respect the environment. Bad publicity leads to consumer pressures and lending institutions are reluctant to loan money to companies with poor environmental records.

> **"Bad publicity stays on the Internet forever"**
>
> *International Seafood By-product Conference (November 2002)*

Discussion

One member of the audience wondered, in view of the competitive advantages involved in maintaining confidentiality, how can we get companies to share information on marketing so that some of these novel ideas can be better put into practice. Andy responded that provincial departments and industry associations like the N.B. Seafood Processors Association can provide marketing advice on a non-competitive basis.

Another question asked was if there was anywhere in the world that is doing a notably good job on waste recovery? The biozyme hydrolysate process which is being installed in Norway and Alaska is a particularly good example of technology addressing product recovery and waste reduction. Also many fish meal plants are getting more and more efficient. In some countries regulations are now driving this movement but its better for the industry to do it on its own for the economic benefits they will derive.

3.2 In house approaches to pollution prevention in the seafood processing industry. James McClare (James McClare Consulting)

Biographical Sketch

James McClare is a native Maritimer, raised and educated in Nova Scotia. He is married with two grown sons and lives in Fredericton, N.B..

Applied Science Diploma from Acadia University, 1962
B. Eng. (Chem) from the Technical University of Nova Scotia, 1964
M. Eng. (Chem), from T.U.N.S., for thesis did pilot plant study of the refining of herring oil, 1965

Past employers:
Canada Packers Edible Oil Refinery in Toronto and Soybean Processing facility in Hamilton, 1965-72;
Nestle Enterprises, main Canadian factory in Chesterville, ON, 1972-79
Elmsdale Foods Div. and UHT Processing Div., Farmers' Co-operative Dairy, 1979-83
President, James H. McClare & Associates, 1983-89
N.B. Research and Productivity Council as Senior Food Process Engineer, 1989-96 where he carried out numerous projects for New Brunswick food and by-product companies, most of whom were seafood processors

He has operated as a consultant out of Fredericton (James McClare Consulting) providing process engineering services to the food and bioresource processing sectors in Atlantic Canada and occasionally in the U.S.A. and internationally. His focus has been assisting clients with the identification or development of process technology, and the design and commissioning of process systems. Mr. McClare has also carried out technical audits concerned with CFIA standards and environmental aspects of plant operation.

Abstract

Effluent loadings in fish plant effluents on the Atlantic coast has recently come to the forefront as a priority concern of the New Brunswick Department of Environment and Local Government, Environment Canada, and area residents. In particular, problems associated with emissions flowing into the environment from Lamèque area sources have made this a priority concern.

Usually one thinks of "end-of-pipe" treatment strategies such as aerobic or anaerobic digestion, flocculation, screening or lagoon type treatment when exploring strategies for dealing with waste water effluent flows. In this paper, some in-house pollution reduction strategies are identified which may be done quickly and at low cost, and past experience in industry in other jurisdictions is summarized.

Typical loadings in other regions are not unlike those in New Brunswick. The literature gives the following:

	Biological Oxygen Demand (BOD)	**Total Suspended Solids (TSS)**	**Flows**
Blue Crab (Mechanized) (Carawan, 1991)	600 mg/L	330 mg/L	20-73,000 GPD
Herring (Carawan 1991)	1200-1600 mg/L	600-5000 mg/L	39,000 GPD
Salmon (Carawan, 1991)	253-2600 mg/L	20-1400 mg/L	50-500K GPD
Shrimp (FRAP Literature)	530-1240 mg/L	240-660 mg/L	
Crab (FRAP Literature)	181-1821 mg/L	80-815 mg/L	
Herring Filleting (FRAP)	3200-5800 mg/L	1150-5310 mg/L	
Salmon (FRAP Literature)	397-3082 mg/L	40-1924 mg/L	

In-house pollution reduction is not new thinking. In the U.S.A. in 1986 the EPA announced a change of emphasis, shifting from "end-of-pipe" approaches to emission control, to prevention mode. They began activities to encourage this approach from industry, and subsequently the "Pollution Prevention (P2)" plan has evolved. In Canada, the Fraser River Action Plan project in British Columbia, has generated a model for in-house pollution reduction in the fish processing industry, well detailed in two publications from this initiative, "Guide for Best Management Practices for Process Water Management at Fish Processing Plants in British Columbia" and the "Technical Guide for the Development of Pollution Prevention Plans for Fish Processing Operations in the Lower Fraser Basin".

Several elements comprise the scope of pollution reduction at the source in this industry; Dry Cleanup, Housekeeping and Maintenance, Screening, Water Conservation and People Management.

Dry clean-up is simply the gathering up of solid waste on the floor and work surfaces and sending for disposal as such, instead of washing down the drain with a hose. This is

done at the end of the workday before the final hose-down and wash-up, also several times during the day, principally at breaks. This also includes the placing of trays to catch solid waste falling off equipment and oozing from leaks.

Housekeeping and maintenance measures include the repair of leaks and table modifications to eliminate spillage sources; ensuring that dry clean-up utensils and bins are regularly available, and the placement of trays to catch drips and leaks. The use of hoses as brooms should be discouraged.

Federal regulation guidelines require that effluent pass through a screen of minimum mesh size of 25 mesh. A number of screening technologies can be used; these include stationary screens; sidehill screens; hydrosieves (rotating drum screens) and vibratory screens.

Water usage should be kept at a minimum. Possible measures here include not leaving hoses running when not in use; finding opportunities for re-use or recirculation of water; replacing flumes with dry conveying methods; use of pistol grip nozzles; changing water flow systems to high-pressure low-flow types.

People management is a critical part of the approach to pollution prevention. Management commitment must be visible. Written standard procedures are recommended. Program developers should ask employees for their ideas, get their input. Good first-line supervision is important in installing and carrying out the programme.

The following are typical of results reported in literature: 60% reduction in organic loadings in shrimp processing (Carawan, 1991); BOD reduction of 69% in a shrimp plant (Carawan, 1996); BOD reduction from 4500 to 1000 mg/L in chicken processing (Carawan, 1996) and a reduction of 45% in a herring filleting operation (Andersen et al).

Discussion

The first question posed was what kinds of savings can be made by using less water? Jim responded that in this Province, where programmes of this kind have seldom been implemented, it is possible to see reductions of as much as 50% in water use. If water goes into an effluent treatment plant the company has to pay for that treatment and therefore treats it as a priority when seeking to make improvements. If it goes into the environment without treatment, unfortunately many plant owners don't see this as a problem. Really the simple answer is that the less water you use the better all round as long as the plant is kept clean.

Another participant wondered how widely available these housekeeping guides are distributed. Jim said that they aren't well distributed in Canada, but in the US there has been a lot of work done on this aspect of in-plant improvements.

One plant manager noted that they have already applied many of these ideas but staff are not always as open to new ideas as they ought to be. Jim responded that this is indeed a problem and suggested that maybe EC should put money into training supervisors.

The question arose if there were lessons we could take from the US situation. What incentives have been applied or what programmes have been put in place to get the improvements observed? Jim responded that pressure from environment departments is one approach, but a better one is to set up a number plants to try this, show that it works and then use these as pilot or demonstration projects for others to observe. This can be a very effective lever.

3.3 B.C. Seafood plant experience with effluents. Paul Bourke (Trident Seafoods, Ucluelet, B.C.)

Biographical Sketch

Graduate of Simon Fraser University - BA in Political Science -1969
Commercial Fisherman - 15 Years, 1969-1984
Vessel owner & Captain in salmon & herring fisheries in B.C.
Co-Founder & President of West Coast Seafood Producers Co-op: 1982-1985
Co-Founder & President of Ucluelet Seafood Processors: 1985-1998

Formerly:

- Chairman of the Canadian Association of Fish Exporters
- Co-Chair of British Columbia Task Force on Fish Processing Waste Water Management
- Participated in several industry missions to Europe to investigate waste water treatment systems
- Member of the Board of Directors of Technomar Canada

Currently:

- Member of the Board of Directors of Ucluelet Seafood Processors Ltd.
- Manager of Surimi sales and Marketing in Europe and Canada for Trident Seafoods Corporation Seattle, Washington.

Abstract

Background

The Village of Ucluelet (V of U) is a small fishing village on the west coast of Vancouver Island, with a permanent population of 1,800 year-round residents. Nearby are the Pacific Rim National Park and the Village of Tofino. Over 1 million tourists per year visit the area.

Prior to 1995, the main industries were fishing- and forestry-related activities, with tourism being the third largest industry. However, in 2002, tourism was the number one industry, fishing was second and forestry related activities were almost non-existent. The fish processing industry in Ucluelet consists of three companies - two large surimi processors and one filleting plant, all using Pacific whiting as the raw material. Shrimp is also peeled in one of the plants.

Surimi is a fish paste that is made by filleting a "white fish" such as cod, hake or Alaska pollock. Then the fillet is minced, washed several times and dried by spinning and pressing the excess water out. Some dry ingredients - such as sugar and sorbitol - are added to this fish paste.

It is then blended and extruded into 10 kilogram trays and plate frozen. This surimi paste is sold to manufacturers who use it as a base ingredient to produce "surimi seafood" such as artificial crab sticks or shrimp products.

The surimi process produces a tremendous amount of BOD (Biological Oxygen Demand) on the receiving environment and contains high levels of suspended solids. When we first opened our surimi plant in 1992 our BOD levels were 18-20,000 mg/L. The regulations called for a BOD of 50 mg/L. Obviously, we were a long way from being in compliance.

Our recovery from round fish to finished product was 13 % in 1992; in 2002 it ranged from 28% to 30%.

Fishing is a highly seasonal business, running from May through October, which closely parallels the tourism industry.

The Crisis of 1994

The DFO, Environment Canada and the B.C. Provincial Ministry of Environment refused to issue a permit to the two seafood processors (500+ employees) in Ucluelet to discharge their screened effluent water directly into the harbour in Ucluelet. In the past, a 12 inch (0.3048 m) pipe, 500 feet (152.4 m) long was utilized at each plant for this purpose. There were no complaints about these two pipes from the local residents or the tourists. There were no fish kills or offensive odours. Despite this evidence we were denied a permit to use our pipelines and forced to hook up to the Village of Ucluelet's sanitary sewer system.

The Regulators' Solution

The suggested solution was to hook up to the municipal treatment system. The fact that it was only designed for residential use was irrelevant to them. The V of U had four settling ponds that were poorly maintained and leaking. They had no trained personnel. The processors gave the V of U their flows and BOD. The consulting engineers to the V of U stated that the two surimi plants produced the same volume and BOD of a city of 50,000 people. If an "end-of-pipe solution" was used, the engineer's estimate of the cost to treat our effluent to meet existing regulations was 40-50 million dollars. Both plants hooked up to the V of U's system with predictable results – offensive odours and many complaints from residents, tourists, fishers and businesses depending on tourists. There was tremendous pressure on the Mayor and council and the plants themselves.

The Processors and Village of Ucluelet's Solution

The end-of-pipe solution was deemed to:

- Be too expensive
- Required too many expensive professional staff
- Required huge capital investments with unproven results

The solution proposed by us, which was accepted, had two major components:

1. A combined outfall

The solution accepted was a combined outfall 1 km long, which discharges outside the harbour (but into a National Park). The effluent from the processors is taken by pipe on land to an area adjacent to the municipal lagoon settling ponds. Once the domestic sewage is treated it joins up with the processors' wastewater (treated at each plant beforehand) and then enters the combined outfall (by gravity) to a point outside the harbour.

This outfall cost $2.4 million. The federal government, the provincial government and the Village of Ucluelet each paid a third of the cost. The fish processors are paying 80% of the Village's cost – spread over ten years. The Village was able to finance the 1/3rd cost for the processors by borrowing the money through the Municipal Finance Authority of B.C.. Each fish plant took a charge against their properties for the capital cost ($350,000 each).

By eliminating the fish processors from the V of U's settling ponds, it freed up the municipal system for residential and commercial use. This was timely, since rapid expansion has taken place in the tourism sector, with over $100,000,000 invested since then in tourist resorts alone...

2. Reduction of Suspended Solids and BOD at the Fish Processors Plants

There were a number of actions that we were able to take to reduce suspended solids and BOD in the wastewater before it had to be discharged.

A. Solutions on the Processing Floor

- ***Use less water by:***
    - Doing a water audit first, then reducing water usage
    - Conveying offal and food-grade material mechanically instead of fluming with water
- Ensure that the ***recovery of food grade material*** is maximized first, thus reducing the suspended solids and BOD load in the wastewater. The surimi plants purchased decanters, which doubled recovery of food grade material and reduced the suspended solids in wastewater.
- ***Separate the streams by:***
    - Not contaminating the effluent which has low BOD with the 20% of the effluent that does have high BOD and suspended solids
    - Treat it separately
    - Or remove it to a reduction plant for treatment, they want the protein and have the equipment to treat it

B. The Impact of Management Techniques

- Convince your management and workers that this is a ***worthwhile investment*** because
    - their jobs depend on it and
    - they live in the local community and thus will benefit with cleaner air and water
- ***Use the best available technology***
    - Keep up to date on developments in the industry
    - Subscribe to publications dealing with these issues
    - Every year, you may have to do pollution abatement pilot testing - so share the cost with other processors
    - Pick a project and have your competitor pick a different one
    - Share the results
- ***Exercise due diligence***
    - Employ progressive efforts to reduce the pollutant load in your waste water
    - Travel and talk to other processors in other provinces and countries
    - Develop a rapport with others with similar situations – preventing water pollution is a non competitive issue
    - Exchange information and experiences
    - This is a global problem – fish processors all over the world, in varying degrees, are facing this problem – in rich and poor countries
- ***Keep it simple***
    - Don't use "cutter pumps" to move wastewater
    - Use gravity and fine screening, which can reduce suspended solids and BOD by 50%, using equipment you may already have, but are not deploying properly

- ***Consultants and experts***
  - Deal with people who have direct experience with fish processing effluent – the ones who don't will learn at your expense and sell the results to your competitors. Employ a professional engineer to evaluate the vendors and their technologies - just because a vendor had some success dealing with effluent from a beef slaughterhouse in Alberta does not mean it will work for you. Employ a professional engineer who deals exclusively with effluent from fish processing plants.

C. Dealing With the Regulators

- Leave the rhetoric at home
- Be humble
- The rules being imposed on you were made up by politicians elected by you and your neighbours
- Sometimes their rules and regulations don't have known technology at a reasonable cost yet
- They know this and they are usually prepared to work with you but you have to demonstrate to them that you are committed - over the long term to improving the quality of the water that you have "used"
- You have derived a benefit from this water - which is a public resource- it is your duty to minimize the negative impacts of this use

Creating a Task Force on Fish Processing Wastewater Management

This task force was created by the province of B.C. and the federal government to co-ordinate the efforts of all industry participants in reducing water use and minimizing the pollutant load into the receiving environment.

Some of the plants discharged into fast flowing tidal waters, others directly into the Fraser River, one of the most valuable and largest salmon runs in the world. Some companies had spent a lot of money trying out different technologies. Others had spent nothing. The industry people soon realized that "compliance" was a non-competitive issue. We had nothing to gain by keeping information to ourselves and everything to lose. The regulators also realized that the "best available technology" did not necessarily mean embracing it would deliver you into compliance. There were no easy solutions at the end of the pipe.

However, there were many things which could be done in the plants to minimize the volume being discharged and the level of the pollution before it reached the end of the pipe.

Out of this Task Force came two very important publications:

1) *How to do a Seafood Processing Plant Water, Waste, and Wastewater Audit*
2) *Best Management Practices and Low-Tech Solutions for Increasing the Efficiency of Seafood Processing Plants*

Both of these publications were authored by Alan Ismond.

The impetus for creating this "task force" was a Wastewater Technology Conference and Exhibition which was held in Vancouver in 1994.The conference was co-developed by the fish processors and the federal and provincial governments. Speakers from the USA, Europe and Canada were invited. The response was tremendous – over 185 registered delegates and 21 suppliers and vendors set up exhibits. The conference covered two days.

This "task force" met regularly for about three years. We all had a better understanding of the problems we faced and gained a much better insight on how to achieve a satisfactory result.

"Preventing water pollution is a non-competitive issue"

Paul Bourke (February 2003)

Discussion

The task force that Paul mentioned elicited a great deal of interest and he was asked to expand on this point somewhat – how long did it take, how did it function and what were the consequences? He responded that it was rough at first, but with the support of the province they finally agreed to meet once a month and were able to generate many new ideas and a number of valuable guides. Two years into the process they held a seminar to capture all they had learned. It was well attended, with over 250 participants in a province that has only 20 major plants in operation, and attracted specialists from abroad. It was obvious that this was a problem that was of concern to everyone in the industry. Following the seminar, a working group of 7-10 people was set up to tour facilities in Europe including fish plants and municipal waste treatment facilities that were attempting to cope with waste from fish plants. They learned a great deal from this, both on what to do and what not to do. In particular they saw a tremendous waste of money in municipal treatment plants that were investing hundreds of millions of dollars to try to accommodate huge flows from fish plants, rather than first investing in reducing and concentrating those flows. From these lessons they shied away from simple end-of-pipe solutions. No one realised at first what economies could be made in-house. This was the real eye-opener.

Another person wondered what the factors were that influenced the length of effluent pipe? There were a number of geographic features that determined this, especially since they were on such an open coast line.

Paul was also asked what factors determined their decision not to employ the Dissolved Air Flotation (DAF) system that they had tested. It was both expensive and at the time there was no chemical they could use that would allow recovered solids to be used in fish meal. The alternative would have been to dispose of it in a landfill a long distance away at great expense ($1,500 per truck load). They are in business today because of the high recovery rates that this forced them to achieve. He noted that its harder to educate the managers to these new processes than the employees.

Another question was asked on whether there were improvements in Dissolved Oxygen (DO) in the area of the former outfall in the harbour after the pipeline was extended into a deeper more active mixing zone outside the harbour? Although there are periods of low DO in this harbour, as in any major fishing harbour, they saw major improvements overall.

Paul was asked if their company is licensed by the province and if so who imposes the limits on BOD? Paul responded that the province is the gatekeeper but DFO and EC must concur on the terms of the permit. The 50 mg/L BOD limit forced their hand, but so did a tripling in the cost of water to $10K a month. In another plant, this increase in the cost of water caused the company to institute a programme in which their contracted cleaners were required to only use a given amount of water and if they exceeded that amount they would pay a penalty. This too was effective in reducing unnecessary waste.

A resident of Lamèque observed that they need someone with ideas like him here. Obviously they had to be pushed, but they seem to agree that it was needed now.

3.4 Integrated management of residues and wastewaters.

Nadia Tchoukanova (Marine Products R&D Centre, Shippagan, N.B.)

Biographical Sketch

Ms. Nadejda Tchoukanova has a Master's degree in technical sciences and an engineer-technologist's diploma (chemistry and chemical engineering) from the Mendeleev Institute for Chemical Engineering, Moscow, Russia. She is a chemist with over 20 years of experience in the field. Ms. Tchoukanova is certified by the Association of Food and Drug Officials/Seafood HACCP Alliance. She is familiar with the design of technological production lines, the assessment of material and equipment requirements, the scientific and technical literature review process and industry outreach. She has developed methods to characterize marine processing industry wastes (carapaces, effluents, etc.) and has developed a process for the treatment of effluent from a marine product waste processing plant that makes use of the organic matter recovered. The process is currently being adapted for industrial use.

Abstract

An integrated management approach for marine products processing plant wastes and effluents and the results of research conducted in cooperation with a company that specializes in the recovery of marine products processing wastes are presented.

The approach involves one step at sea and four steps in the plant.

1. Reducing pollution begins on board the fishing vessels, using good catch icing and storage techniques to preserve the freshness of the catches.

2. A good knowledge of the physical and chemical characteristics of processing plant wastes and effluents is critical. It requires:
   (1) preparing an inventory of all plant wastes and of wastes that can potentially contaminate effluent;
   (2) determining the degree of contamination of each waste stream of each step of each type of production;
   (3) quantifying each waste, each waste stream, each effluent; and
   (4) determining the biochemical composition of the wastes and identifying their value-added potential. The results obtained provide the basis for the subsequent steps.

3. Processing marine products generates large volumes of waste (65 to 85% of the raw material). An integrated waste management strategy requires:
   (1) the development of techniques for isolating and recovering wastes before they come in contact with or become diluted in water; and
   (2) the development of techniques for the handling, preservation and storage of these wastes before their shipment to specialized waste recovery plants or composting sites.

   Every dollar invested in the proper management of processing wastes can result in a savings in subsequent effluent treatment.

4. Marine products processing requires large quantities of potable water, which generates large volumes of effluent. The greater the volume of effluent, the more costly it is to treat. Integrated management of potable water and effluent consists of:
   (1) reducing the use of potable water and therefore of the volume of effluent produced;
   (2) separating high organic waste streams and directing them to the appropriate treatment system; and
   (3) separating waste streams containing little or no organic matter for reuse or release into the environment.

5. A number of effluent treatment technologies exist. The costs of physical treatment are very high and can be justified only if the recovered solids have high value-added potential (flavours, enzymes, etc.).

   Physical-chemical treatment includes chemical coagulation-flocculation of solids, followed by aggregate separation by sedimentation, centrifugation or skimming. Physical-chemical treatment is less costly and the recovered solids are suitable for animal consumption, provided the coagulant used permits it.

   Biological treatment includes the use of organic solids as nutrients for living organisms, such as bacteria and algae. Biological treatment should be considered if the effluent is contaminated with toxic compounds, decomposed organic matter, etc.

MPRDC, in close collaboration with the Saint Laurent Gulf Products Ltd. plant in Bas-Caraquet, N.B., has developed a process for the recovery and reclamation of suspended solids (SS) from "stickwater", an effluent with a very high protein and fat content. A solution involving the use of coagulation-flocculation was developed in the laboratory. In the treatment of the samples, 96 to 98% of the suspended solids, 34 to 55% of the proteins (Total Kjeldahl Nitrogen - TKN), and up to 95% of the fats were recovered, while BOD was reduced by 54 to 81% and COD by 56 to 61%. The recovered waste consists primarily of proteins (52 to 55%) and fats (41 to 44%). The proteins contain essential amino acids and 10% of the recovered fats consist of Omega 3 essential fatty acids. In pilot plant tests, a SS recovery rate of 94 to 98% and BOD and COD reductions of 68% and 67%, respectively, were obtained. The waste recovered and dried contained 51% proteins, 39% fat and 3% ash, and is suitable for animal consumption.

Discussion

No questions arose from the presentation.

3.5 The importance of water-pinching. Mauricio González (Marine Products R&D Centre, Shippagan, N.B.)

Biographical Sketch

Dr. Mauricio González has a Ph.D. in bioprocess engineering (Universidad Catolica de Chile, Santiago, Chile) and a professional degree in biochemistry (Universidad de Chile, Santiago, Chile), and is in charge of technology watch and technological transfers at the MPRDC. He has experience in bioprocessing, industrial microbiology, biochemistry, industrial-scale technological adaptation and technology watch strategy. During his doctoral studies, he did research on industrial extraction and fermentation techniques, (solid and semi-solid culture substrates), the identification of derived products, and the characterization/optimization of microbiological environments. His professional experience includes the use of various analytical techniques, the design and optimization of industrial scale bioreactors as well as ozone reactors and thermal exchangers.

Abstract

Water Pinch (WP) is a technology that can be applied to seafood processing plants in order to reduce the volume and treatment costs of their effluents. The application of this technology can lead to savings by: 1) decreasing the use of fresh water; 2) decreasing the volume of effluents; and 3) improving the characteristics of effluents for their treatment to meet environmental regulations or for product valorization purposes.

WP has been used by several important industries around the world with water savings ranging from 20 to 60%. WP is a systematic technology for the analysis of water networks. It is based on an accurate water assessment in the processing plant, considering the inputs/outputs flows of water and their characteristics (solids concentration, temperature, pH, etc). Such assessment is needed to determine how to improve the efficiency of the water network as a whole system. The main objective of WP is the reduction of fresh water usage to decrease water costs. With the reduction of fresh water

usage, there is a reduction in the volume of effluents and consequently a lower demand on effluent treatment facilities.

WP is a relatively new technology that was applied to water management in 1994, but whose fundamentals were initially established for energy savings in the 70's. The application of this technology requires some engineering skills and specialized software. WP allows the identification and optimization of water reuse, recycling and regeneration, and constitutes a preliminary strategic step for effluent treatment in industrial sites such as seafood processing plants. The concentration of some valuable products by the segregation of streams can facilitate their recovery and thus generate economic opportunities. With stream segregation, or the "no mix approach", it becomes easier to process streams with desirable characteristics than to deal with single dirty streams that contain valuable products at lower concentrations, mixed with toxic chemicals or other unwanted compounds. Effluent treatment to meet environmental regulations can also be improved cash-wise, because streams that need less treatment are then obtained.

General approaches to water minimization via WP can include: 1) process changes by replacing the technology employed; 2) water reuse where wastewater from one operation can be directly used in another operation; 3) regeneration reuse where partial treatment of wastewater removes contaminants and the partly treated effluent is reused in another operation; and 4) regeneration recycling where water is reused in an operation through which it has already passed.

Advantages of WP includes better water and effluent management decisions while at the same time improving process efficiency. It also can be applied during the initial design of the process or as a tool to guide process modifications due to changing circumstances (financial, environmental, etc.). WP thus enables to determine the minimum amount of water necessary (recycle loops, reuse cascades, etc.).

However, the real savings lie in the future, when on-site treatment will be required prior to discharge. The reduced wastewater flow can be expected to yield important savings in the capital cost of any future treatment plant (in some cases such savings have been estimated to be up to 50%). Furthermore, at the higher concentrations resulting from lower flows, it becomes feasible to introduce new treatment technologies for the complete recovery of product species from the effluent, thus virtually eliminating pollution. As a general rule, larger water savings are expected the greater the complexity of the water system and volumes of water used in a processing plant.

In the case of the food and beverage industry, water savings can be expected to range between 30 to 40%. In summary, the application of WP can decrease the use of fresh water in seafood processing plants and save money by decreasing production costs. It can also decrease the volume of effluents. This will increase the concentration of valuable products that can be extracted, lower the volumes of effluents to be treated, as well as lower the flow rate and volume of effluent for the treatment facility. WP applied to seafood processing plants can thus be a worthwhile preliminary step for effluent treatment from the environment and optimisation of effluents points of view.

Discussion

Mauricio was asked to explain how you reduce risk of cross-contamination of waste streams. His response was that there are specific technologies that have to be evaluated in each case, there is no single solution.

This raised the question of how applicable this technology would be in a plant utilising sea-water for some of its processes and other in-plant uses. The response was that you would need to evaluate if the mixing of fresh and sea water may be useful in achieving the purpose of reducing water use and effluent emissions and increasing recycling or if they need to be maintained as separate streams in order to achieve these ends, just as for any other freshwater process streams.

3.6 Flocculated system technologies and application to fish meal plants. Chris Murray (Epsilon Chemicals, Truro, N.S.)

Biographical Sketch

Chris Murray graduated from the Nova Scotia Agricultural College in May, 2001 with a bachelor of science in agriculture. He majored in agricultural mechanization. During this time of study he took various courses on fundamentals of food processing, soil and water, water and water quality, environmental impacts and resource management. He has been working with Epsilon Chemicals Ltd. for two years as a technical sales representative. During this time he has set up two waste water treatment plants and is still currently involved in the maintenance and running of these systems.

Abstract

Executive Summary:

Epsilon Chemicals Ltd. in conjunction with the Biotechnology Department of the Alberta Research Council and with partial funding from the National Research Council's Industrial Research Assistance Program, has developed an environmentally friendly technology to treat the liquid effluent from the meat, hog, poultry and fish industries.

This technology involves an adjustment of the pH of the effluent to the isoelectric point of the proteins present, prior to the addition of Epsilon Chemicals Ltd. new biodegradable polymer ***EnviroFloc***^{TM} . The treated effluent is transferred to a specifically designed treatment system. A separation occurs and the solids are removed from the clear liquid phase. This liquid phase has undergone a reduction of Total Suspended Solids (TSS) (90 - 95%), oil/grease (O/g) (90 - 95%), Biochemical Oxygen Demand (BOD) (60 - 80%) and protein (80 - 98%). The variations in pollutant removal is a result of the different types of effluent used.

The sludge removed from this system can be used in a rendering process. On analysis the sludge has a free fatty acid (FFA) content of 3%, a solids content of 25 - 35%, a pH of 5 and a high protein and fat content. Presently, sludge produced from a hog processing operation and a separate rendering operation is being processed at the renderer into number 1 tallow and a meat and protein meal.

Food Industry Background

The meat, poultry and fish processing industries use large volumes of water on a daily basis. Approximately 60% of the water is used during processing and 40% is used during the clean-up operation. The potable water used during processing becomes heavily contaminated with BOD, TSS and O/g prior to being discharged to a waste treatment system.

The average values for BOD, TSS and O/g in the various effluents are as follows.

Industry	**BOD mg/L**	**TSS mg/L**	**O/g mg/L**
Beef/hog	760	500	185
Poultry	1800	300	200
Fish	1020	640	190
Rendering	7000	3820	2600

The major contaminants in effluent from food processing plants are those that contribute to the high Biochemical Oxygen Demand (BOD). A high BOD means that large amounts of oxygen are required to decompose the effluent. If such effluents are discharged into a natural waterway the oxygen content of the water can be reduced to the point where fish can suffocate. Other troublesome components of the effluent are suspended solids and oil and grease.

The use and handling of water differs greatly in the various industries. For example, the fish industry uses considerable volumes of water in transporting raw material throughout the processing facilities by means of fluming. This water becomes heavily loaded in BOD, TSS and O/g. However, in the meat and poultry industries little or no fluming is encountered. Water recirculation is used in the poultry industry for removing eviscerated offal. However, water recirculation is not prevalent in fish or meat processing. All industries use large totes of water in several of their unit operations, e.g.: the fish industry use totes of water to gently thaw frozen fish, the hog industry uses totes of water to scald the hogs and the poultry industry uses totes of water for gently thawing poultry. Water in these totes becomes heavily saturated in soluble BOD and causes tremendous problems when it is discharged into the drain systems of plants. Ultimately, these concentrated solutions find their way to the waste water treatment plant.

Waste treatment technologies used for the treatment of food processing effluent are similar to those technologies primarily developed for the hydrocarbon and pulp and paper industries. The problems encountered with these processes are that they are expensive and they must be adapted for use with food effluents.

For example, due to the large quantities of batch processing present in the meat, poultry and fish industries, the resulting liquid effluent emanating from these plants is not of a homogenous nature. Consequently, when there is a surge in the effluent volume load the resulting waste treatment facility is unable to handle the increased solid loading. If the waste treatment facility uses a dissolved air flotation (DAF) system, and the system encounters a heavily loaded surge, it is unable to cope and usually the treatment in disrupted for approximately 20 minutes. What this means is that an average plant discharging approximately 5,000,000 l/eight hour shift would discharge 208,333 l (55,036 US gal) of effluent with little or no treatment.

Microbiological treatment is seldom used in these industries due to the retention time required for the microorganisms to function. This type of system generally requires a large area to be effective. Unfortunately most processing plants are located in large populated areas and space is of a prime consideration. Therefore, the processing plants are unable to give the retention time required. Also, these systems are inefficient when the effluent treated is not of a homogenous nature. Effluent surges with heavily loaded BOD, TSS and O/g usually disturb the microbial ecosystem and recovery times of up to 10 hours are usually needed.

EnviroFloc^{TM} has proven effective in reducing the BOD, TSS and O/g components of effluent streams. In a fish processing plant in Vancouver, the BOD in the waste water was reduced by 60 to 80% and a substantial reduction (95%) in the suspended solids and the oil and grease was obtained. The entire process took approximately 30 minutes. The process also works in poultry and meat processing plants.

Besides cleaning up effluent, ***EnviroFloc***^{TM} technology offers the added feature of producing a reusable sludge. Currently available technology cannot do this because the chemicals in the process are potential carcinogens and the sludge must therefore be landfilled in approved waste disposal sites at considerable expense. ***EnviroFloc***^{TM} uses a naturally-occurring, biological polymer that is biodegradable, and can be recycled and rendered to produce a protein source for use in making fish or animal meal.

It is estimated that recycling the protein in a plant producing five million litres a day of effluent will generate $100,000 in annual profit.

Conventional waste treatment technology has high capital costs and operating costs of $0.50 - $4.80 Cdn per cubic metre. Costs associated with the ***EnviroFloc***^{TM} technology fall into the range of $0.30 - $0.60 Cdn per cubic metre.

These cost savings are particularly important to the food processing industry because its profit margins are very narrow. Also, the industry in Canada is facing stiffer environmental regulations concerning effluents. Penalties of $1M per year for non-compliance are not uncommon.

Results

EnviroFloc^{TM} has proven to be effective on meat, poultry and fish effluents. The average results are as follows:

	BOD mg/L Raw	BOD mg/L Treated	TSS mg/L Raw	TSS mg/L Treated	O/g mg/L Raw	O/g mg/L Treated	Protein g/l Raw	Protein g/l Treated
Beef & Hog	760	325	500	25	185	16	0.515	0.151
Poultry	1810	209	280	42	183	49	0.565	0.005
Herring	1800	662	780	20	60	12	0.920	0.104
Salmon	519	168	260	90	53	9	0.096	0.014
Rendering	7710	1872	6263	31	2658	17	2.83	0.350

Summary

As can be seen from the above results, ***EnviroFloc***^{TM} is effective against all proteinaceous effluents treated. Epsilon Chemicals Ltd., is presently supplying turnkey wastewater treatment systems incorporating the ***EnviroFloc™ Technology*** to the food industry in Canada.

Discussion

It was observed that in an application of this technology in fish plants, due to the high lipid content and the desire to avoid oxidation, it would be highly desirable to use nitrogen injection rather than air to avoid putrefaction of the recovered protein. Chris responded that this would most probably be possible, though they have not actually attempted to do this. All that the injected air does is to make the sludge rise and any gas could theoretically achieve the same aim.

Another participant wondered what is the exact nature of the polymer used. Chris responded that this is a well kept secret but it is 100% biological and certified by the government as being of food-grade quality.

Getting into specifics of treatment volumes, the question was posed, if you segregate high load streams, what is the lowest volume this technology could work on? The answer is that there is no minimum quantity – it is scalable technology and the price would vary with size of the equipment. Volumes from as low as 150 to over 1,200 US gallons (567.8 to 4542.40 l) per minute have been treated in operational conditions. When the BOD is higher you simply add more polymer. Costs range from 30 to 60 cents Canadian per cubic metre of effluent treated.

This led to the question of whether the technology had been tested in New Brunswick fish plants, and if so, what the results and costs were. This has not yet been tested and the company works on a response to requests basis rather than carrying out their own research. Nevertheless the cost estimates of 30 to 60 cents per cubic metre would be a good rule of thumb for this industry as well.

More specifically Chris was asked if they have experience working with *stickwater*, the final wastewater stream from fish meal operations which contains high levels of suspended and dissolved solids and a certain amount of oil and grease. He noted they have only limited experience in this area (one trial perhaps).

Paul Bourke, who had been a part of earlier trials of this technology in British Columbia wondered why they moved more into meat processing from the fish sector. Chris responded that this was because that is where the demand has come from and the company, like any service industry, is demand driven.

Finally, a question was posed on the average cost for the chemicals used in the process. Chris responded that in one local application (Larsen meat packing plant in N.S.) chemical costs run at $1,500 per week. Labour is not an issue. It runs itself once installed, but Larsen has chosen to employ two people on shifts simply to monitor the system and mix the polymer.

Panel discussion on in-plant modifications

Moderator: John Castell

Panel Members: Speakers

The first day's proceedings were concluded by holding a panel discussion which focussed on the presentations just heard, but permitted audience interaction on any issue that had not yet been given sufficient coverage. The role of the moderator was simply to field questions and to ensure that they were directed appropriately to the panel composed of the speakers in the first sub-theme on in-plant modification and treatment processes. The moderator, John Castell, also noted that this was an opportunity for those whose questions could not be asked before due to time limitations to bring them forward now.

The moderator began the discussions by directing a question to Paul Bourke asking him to elaborate on the cost return of equipment due to increased product recovery in their experience at Ucluelet. In order to respond to this question, Paul had to explain a bit about the process of producing surimi. The fillet is taken and then they wash away any undesirable residual odour and flavours. Normally the screw press used allows fine particulate to escape and it is this which can be recovered in the system of decanters and centrifuge that they eventually instituted. The second wash water can also be put into the decanter. The output from this recovery operation can go back into high grade product at \$1.50/lb. (\$3.31/kg), the quality is that good. They also recover poorer quality residuals worth 40 or 50 cents a pound (\$0.88 to \$1.10/kg) which they have found markets for. Together the value of these new product sources, which constituted a recovery of formerly lost product of 18 to 30% of production volumes, was able to pay back the capital cost of installation of the decanters and centrifuge in only 40 days.

Andy Woyewoda added that the surimi process is always kept cold so bacteria never have a chance to proliferate and thus high-quality food-grade product recovery is practical in that process.

In response to this, the moderator directed another question to Chris Murray asking if he could control the temperature in his system. He responded that this is not presently possible because the applications they are installing do not demand it. There is no reason to believe that it could not be incorporated into the design of a specific system.

Andy Woyewoda wondered about "trials" that Chris Murray had discussed. How are these done and who pays? Chris responded that the trials are paid for by the company considering the application of this technology to their processes but this is scaled to the existing situation and if they have a lot of the needed equipment on site already, as is often the case, the trial can be very inexpensive. During trials they will do full analysis at the lab and will calculate optimal dose rate for the polymer. Their chemist will be on site for the full trial (often several months) until the specific application of the methodology to that plant's production lines is perfected.

It was pointed out by a participant that the BOD of the final effluent in Paul's case is 3,000 mg/L and this would almost certainly fail to meet requirements for a 96-hour fish bioassay LC50 under the *Canada Fisheries Act*. Paul agreed. They aren't happy with these numbers and are still working to improve this. In the interim, they ameliorate the problem by combining their effluent with the treated municipal waste stream and diffusing the combined outfall. But they keep trying new technologies every year to get the BOD numbers down. He reiterated that they had tried Epsilon's process, which didn't work because of the high TSS levels.

In a follow-up question Paul was asked if the Wastewater Technology Centre had offered them advice and if this was helpful. He responded that they did indeed offer advice during the course of the several years during which improvements were being investigated. However it was not their advice specifically that led to the solution now employed.

It was noted that many plants in this region use a lot of seawater. What does this do in terms of treatment and recovery? Andy Woyewoda noted that there are techniques that involve dissolving fish in salt water (though lobster, crab and finfish differ in this regard) so it is true that salt water will potentially cause greater losses of soluble nutrients and product. Paul Bourke added that canneries in B.C. aren't allowed to dump seawater used to transport the fish into the harbour. The boats they unload must bring in clean salt water to pump the fish into the plant, then the boats must go out to sea and dump the resulting blood water according to specific guidelines. Chris added that in salt water applications their ***EnviroFloc***^{TM} process works but it isn't quite as effective.

Another participant wanted to discuss in-plant modifications like water pinching. Health issues here are in the forefront. What are the implications from a health standpoint of instituting this technology? Mauricio González agreed that health issues are always the foremost consideration but noted that they can take this into account and still produce important water savings.

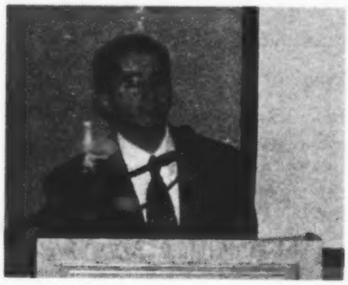
The moderator asked if the flocculant Nadia Tchoukanova was testing was being used in an actual commercial fish plant operation and whether it can be used to produce animal feeds. Nadia answered that this is still being tested and not in full operation but it is an excellent coagulant and will produce a perfectly acceptable food supplement. She added that the product possesses antioxidant properties.

Sub-theme B: End-of-pipe applications

Chair: Simon Courtenay

The Chairman explained that the presentations in this session would not be followed immediately by a discussion and requested that questions instead be reserved for the panel presentation that followed. Both presenters would participate in that panel and accept questions at that time.

3.7 Biological wastewater treatment alternatives for the seafood processing industry. José Molina (ADI Systems Inc.)



Biographical Sketch

José Molina is an environmental engineer employed with ADI Systems Inc., based in Fredericton, N.B.

Abstract

This presentation dealt with the full range of currently available biological treatment in the seafood processing industry under the following headings:

Wastewater generation in the seafood processing industry

- Terminology/definitions

Biological process technologies

- Anaerobic
- Aerobic
- Biological Nutrient Reduction (BNR), tertiary treatment.

Case Studies

- Fishmeal processing, clam processing

Biological treatments include aerobic, anaerobic and other tertiary means. Ideally one should look for in-plant solutions before going out into the environment. ADI specialises in biological treatment systems mainly for industry, but also for some municipalities. Every fish processing plant is different and each line in each plant makes for complications.

Wastewater mainly comes from contact between water and fish – cooling, freezing, as a conveying medium, peeling or separating parts, cooking, cleaning, etc. As water contacts the raw material or the cooked product, organic matter including particulates and oil is suspended and dissolved in the water stream, giving Total Suspended Solids (TSS) and Total Dissolved Solids (TDS), which combine to give an organic load measured as Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). These in turn can be divided into fractions representing the Total, Soluble and Particulate fractions. BOD in fish plant wastewater ranges from 500-5,000 mg/L (the measure of O_2 required to degrade the organic matter present) compared to sewage which may be 200-250 mg/L. These measurements are taken over a five day period. COD is always higher – 1,000-20,000 mg/L and is measured over a two hour period.

TSS measures the portion that can be removed by a fine filter. VSS is the "volatile" or organic portion of TSS and contributes to BOD and COD. The typical range is 500-5,000 mg/L.

Nitrogen (N) can be a major ingredient in fish plant waste water. In limited quantities N is useful in the environment because it is a nutrient and promotes growth, but in larger quantities it can be a pollutant leading to eutrophication. It is generally found in several organic and inorganic forms. It originates from protein and other organic matter. Total Kjeldahl Nitrogen (TKN) is a measure of the organic portion of N that is found in compounds like ammonia and which can be most harmful to the environment. It generally ranges from 50-500 mg/L.

Phosphorus (P) is also a macronutrient used by organisms that can lead to eutrophication. It can enter waste water streams from sources similar to N (e.g. proteins) but also from the use of detergents and phosphoric acid as cleaning agents. It is usually found at lower concentrations than nitrogen (10-100 mg/L).

The longer the contact with water, the more soluble products leach into the water. Fish protein is quite soluble which makes it harder to remove so we have to count on bacteria to break it down – screens don't help. Some soluble material can be removed in a physical/chemical system like Dissolved Air Flotation (DAF). But the sludge that results from a DAF system many times cannot be sold or made use of due to the chemical coagulants added in the process and thus winds up in landfill.

Another option is biological treatment. Bacteria or sometimes algae are used to digest the waste organics. In fact bacteria make up 85% of the sludge biomass in this type of treatment system. Septic systems and sewage treatment lagoons are examples of biological treatment. Some systems are referred to as "autotrophic", that is they can survive on inorganic carbon. Others are "heterotrophic" and depend on availability of organic carbon. Either can be aerobic (requiring the presence of oxygen) or anaerobic (thriving in the absence of oxygen). Biological technologies support all these forms of bacterial growth. Macronutrients required for bacterial growth include carbon, hydrogen, oxygen, nitrogen and Phosphorus.

Aerobic processes include nitrification and sulphur oxidation. This form of digestion is energy intensive because it requires infusion of oxygen. It also produces large quantities of sludge. But it does significantly reduce the presence of N and P in the effluent stream because bacteria are composed of 8% N and 1.5% P and thus they take up large amounts of these materials from the effluent stream. However, that leaves a large quantity of sludge to be dealt with. In its favour, it is a known and proven technology.

In anaerobic (anoxic) conditions, de-nitrification occurs. Anaerobic conditions can also result in H_2S production. But this form of treatment produces much less sludge and requires less energy input. A useful energy source is produced in these processes in the form of methane (CH_4). The methane can be burned to provide heat or energy for various plant processes. This form of treatment is much more stable and less prone to "shocks" than aerobic treatment, but it does require pre-treatment to remove TSS and fats, oils and greases (FOG) and it does not work as well in salt water or low temperature situations or where operations are seasonal in nature. All of these deficiencies can be accommodated through a number of patented improvements in design (e.g. ADI-BVF®). Anaerobic treatment would be preferable in all fish plants because it is environmentally friendly. However it is a very complex and delicate balance that needs to be maintained.

Editor's Note: The oral presentation described a wide range of process and treatment systems in technical detail giving the pros and cons of each and also used two case studies, one on fish meal processing and one on clam processing to illustrate the issues and opportunities. This information is available in the full presentation which can be obtained from the author.

3.8 Approaches to wastewater treatment - Lagoons, odour problems and Zenon technology. Graham Gagnon (Daltech)

Biographical Sketch

Graham A. Gagnon, Ph.D., P.Eng. is an Associate Professor at Dalhousie University, Department of Civil Engineering and Associate Director of the Centre for Water Resources Studies (CWRS). He has a Ph.D. in Civil Engineering from the University of Waterloo and a B.Sc. in Environmental Engineering from the University of Guelph. Dr. Gagnon's expertise covers the wide range of water and wastewater process design. He has his research funded by industry (aquaculture, agriculture, chemical manufacturers, and power companies), water utilities and federal governments (US and Canadian) to investigate emerging water/wastewater treatment issues.

Abstract

This presentation reviewed new and traditional technology used to treat wastewater which has characteristics similar to seafood processing wastes. Particular reference was made to biological treatment systems both aerobic (system operated in the presence of oxygen) and anaerobic (system operated in the absence of oxygen). Definitions and operating system characteristics were presented for these systems. In addition to suspended biological systems, fixed-film or biofilm processes were discussed. In particular a case study for peat filtration was presented as a potential biofilm support system. Finally, advanced technologies were discussed. Case studies for membrane bioreactors and general characteristics of membrane treatment were presented and discussed.

For further information concerning this presentation, please contact Dr. Gagnon by phone (902) 494-3268 or e-mail graham.gagnon@dal.ca .

Panel discussion on end-of-pipe modifications

Moderator: Thierry Chopin (UNB Saint John)

Panel Members: Speakers

The first question raised was to determine what the differences are between fish plants across Canada and elsewhere in the world. José said that there are no biological treatment systems in use in the seafood industry in Canada (there are in the US), but some fish plants do pump into municipal systems with biological treatment which often get overloaded. In fact, there are relatively few examples world-wide of fish plants with biological treatment systems. Most have some form of physical/chemical treatment with municipal treatment in some cases.

Jim McClare wanted to expand on the need to replace membranes frequently at high cost, an issue raised in Graham's presentation. Graham responded that there are two high cost factors: pressure and energy costs; membrane replacement costs. The second is highly variable. It is a lot better than it was 15 years ago because they are more durable now and don't need to be replaced as often. They could last as long as 5 to 15 years now. Jim added that this could make it a very expensive technology. Graham agreed, but said that sometimes the circumstances warrant the expense.

Another question pertained to what advice ADI had offered to the Island Fisherman Co-operative, Ltd. in response to their studies at the fish plant in Lamèque. What is the best treatment system in that situation? José noted that there is a whole range of potential technologies that will work and the Co-operative must decide which to adopt based on all their own assessment of their operational needs and constraints. Biological treatment may not be feasible in the case of this fish plant. While there is good reason to try and diminish Chemical Oxygen Demand (COD) because it represents lost product, there are many reasons why this cannot be optimised and there will always be some waste.

Angélina Cool wondered how the industry might put together studies and raise funds for pilots so that the individual plants don't have to pay. José noted that some companies will do demonstration projects on speculation of future business opportunities.

Inka Milewski asked how important regulations are in determining the progress of the applications of these technologies in the industry in N.B. Graham said that historically it has been an important issue, but there is a strong awareness across the industry of the obligation not to pollute regardless of legislation and potential penalties. Enforcement should be the last option. José added that in many cases the drivers are not the regulators but the energy costs. Where methane can be generated anaerobically, there is a considerable cost saving. Public relations is also a big driver. Graham added that there is also the opportunity to profit from a secondary product.

Mauricio González observed that the seasonality of the fishing industry in this region makes the biological treatment option much more difficult. José pointed out however that anaerobic bacteria can lie dormant for months at a time. This is not so of aerobic systems. This is why aerobic systems are not recommended for seasonal operations.

Andy Woyewoda asked what happens to Nitrogen (N) in aerobic systems since it is not removed by the process. Also, spoiling seafood begin to smell; is there an odour problem? Graham replied that a subsequent anaerobic system is required to take out N. Anaerobic systems control odour better. José added that all biogases can also be collected in an aerobic system.

On a different line of questioning, a participant enquired if anyone had looked at artificial wetlands systems as a form of biological treatment. Graham agreed that they are a possibility, but the big issue is the large space requirement. Another big problem is the potential kill of plants that the system relies on. Most systems of this kind can only deal with up to about 1,000 mg/L concentrations of N.

Another participant asked if it would be possible to utilise the peat moss that is abundant in this region to form a part of the solution? Graham said that there are a couple of companies that make peat filters, for example, but whether the peat in this area can be used for this purpose needs to be studied. The downside of peat filters is that they need a fairly clear waste stream.

Sub-theme C: Receiving environment applications

Chair: Simon Courtenay

Once again, participants were requested to withhold their questions until all presenters on this sub-them had spoken. An opportunity was afforded to pose questions of all the presenters collectively in the panel session that followed.

3.9 Could the aquaculture of shellfish and seaweed work with fish plant effluents as it works with finfish aquaculture? Thierry Chopin (UNB, Saint John, N.B.)

> **"The solution to nutrification is not dilution but conversion"**
>
> *Thierry Chopin, February 2003*

Biographical Sketch

Dr. Thierry Chopin was born and educated in France. He obtained his Doctorate from the University of Western Brittany, Brest, France. He moved to Canada in 1989 and is presently Professor and Chair of the Biology Department at the University of New Brunswick (UNB) in Saint John.

As a member of the Centre for Coastal Studies and Aquaculture and the Centre for Environmental and Molecular Algal Research at UNB (Saint John), his work focuses on the ecophysiology and biochemistry of seaweeds of commercial value and the development of integrated aquaculture systems (fish/shellfish/seaweed).

He is Vice-President/President Elect of the Phycological Society of America, and Treasurer of both the International Phycological Society and the Aquaculture Association of Canada. He is an advisor to the International Foundation for Science, in Stockholm, a member of the Steering Committee of the Bay of Fundy Ecosystem Partnership, and a member of the Board of Directors of the Coastal Zone Canada Association, and a member of the Editorial Board of the journal *Aquaculture International*. Dr. Thierry Chopin is also Honorary Vice-Consul of France.

Abstract

On a regional scale, finfish aquaculture can be one of the significant contributors to coastal nutrification. Contrary to common belief, even in regions of exceptional tidal and apparent "flushing" regimes like the Bay of Fundy, water mixing and transport may be limited and water residency time can be locally prolonged. Hence, nutrient bioavailability remains significant for a relatively long period of time in some areas, especially when aquaculture operations are geographically highly concentrated.

Understanding the assimilative capacity of coastal ecosystems under cumulative pressure, then, becomes critical. In its search for better management practices, the aquaculture industry must develop innovative and responsible techniques to optimize its efficiency and diversify, while ensuring the remediation of the consequences of its activities to maintain the health of the coastal zone. To avoid pronounced shifts in coastal processes, conversion, not dilution, is the common sense solution, and has already been used for centuries in Asia. By integrating fed aquaculture (finfish) with organic and inorganic extractive aquaculture (shellfish and seaweed), the "wastes" of one resource user become a resource for the others. Such a bioremediative approach provides mutual benefits to co-cultured organisms, economic diversification through the production of other value-added marine crops, increased profitability per cultivation unit, and cost-effective means for reaching effluent regulation compliance by reducing the internalization of the total environmental costs.

These concepts will be discussed and illustrated by the results of our on-going project supported by AquaNet, the Canadian Network of Centres of Excellence in Aquaculture. I will also demonstrate that seaweeds can be excellent bio-indicators of nutrification/eutrophication revealing symptoms of environmental stress and measuring the zone of influence of an aquaculture site.

The aquaculture industry is here to stay in our "coastal-scape": it has its place in the global seafood supply and demand, and in the economy of coastal communities. To help ensure its sustainability, it needs, however, to responsibly change its too often

monotrophic practices by adopting polytrophic ones to become better integrated into a broader coastal management framework.

The solution we are developing for year-round bioremediation of fish aquaculture effluents in the Bay of Fundy (free from ice cover in the winter) is maybe not directly transferable to the treatment of seasonal, and highly variable, fish plant effluents in regions completely covered with ice during winter, as in the Lamèque-Shippagan region. Extractive aquaculture requires the availability of inorganic nutrients for seaweeds and small organic particles of a size that can be filtered by shellfish; large pieces of seafood discharged by fish/shellfish plant effluents would not be directly available to the extractive component of an integrated aquaculture system. Moreover, the characterization (chemical composition, inorganic/organic ratio, etc.) and variability (ever-changing types of effluent according to the seafood being processed, using many different techniques) of these fish plant effluents, their freshwater/seawater ratio and their turbidity need to be much more precisely documented before candidate species for aquaculture can be selected.

The proposed solution of extending, or moving, the end of the discharge pipe by a few hundred metres, in what appears to be a rather enclosed embayment such as the Bay of Lamèque, will probably not change the situation much or will shift the problem to another location. I do not think that the functional components of the ecosystem change significantly within a few hundred metres; consequently, the assimilative capacity of the particular system remains similar and prone to continue to being exceeded.

The most logical solution, but not necessarily the cheapest in the short term, would be to modify processes at the in-plant level, or just at the end-of-pipe level, to capture what is presently seen by some as "wastes", but which could be value-added "treasures" for others in the long term. When fish plant effluents are discharged in the receiving environment, their conversion to reusable compounds by extractive functional components of commercial value (bacteria, algae, molluscs, etc.) is a long process, marked out by many "ifs" along the road of remediation.

We have to understand that the green tide problem (mostly of the sea lettuce *Ulva lactuca*), which has been blooming more critically over the last few years, is, in fact, a problem that has been in the making for quite a long time. As we have to admit that we are not yet particularly good at understanding, and then modelling, the assimilative capacity of coastal systems, we do not know when we reached the level of "the straw that breaks the camel's back", with the serious eutrophication situation we now experience. It also means that even if a solution, or most probably a combination of solutions, is implemented in the near future, we should not lure ourselves into believing that a quick fix will be developed over one summer… the problem has been cooking for a while and it will take some time to fix it, with a coastal system that has been significantly enriched over the years.

3.10 Gauging the assimilative capacity of coastal receiving environments. Graham Daborn and Mike Brylinsky (Estuarine Research Centre, Acadia University, Wolfville, N.S.)

> **"Gauging assimilative capacity isn't really about how much contamination the ecosystem can take – it's about how much we as a society are prepared to accept"**
>
> *Graham Daborn, February 2003*

Biographical Sketch

Graham Daborn is currently Director of the Acadia Centre for Estuarine Research, and Professor of Biology at Acadia University. During the last 30 years Daborn has been involved in many kinds of research dealing primarily with aquatic ecosystems: lakes, ponds and estuaries, particularly the macrotidal estuaries of the Bay of Fundy system. The initial challenge was to address the environmental implications of tidal power. The Acadia Centre for Estuarine Research was established in 1985 to focus attention on estuarine environments. His research has covered the full range of topics in estuarine research, from the primary production of phytoplankton, benthic diatoms and saltmarshes, to the population dynamics, growth rates and feeding relationships of crustaceans, fish and birds. Daborn is currently also involved in enhancing public awareness of environmental socio-economic issues, in supporting the Atlantic Coastal Action Program (ACAP), of which the Clean Annapolis River Project is the flagship. He is a theme leader for the Policy and Governance theme of the Canadian Water Network, a Network of Centres of Excellence aimed at understanding the Environmental Implications of Clean Water. Daborn also chairs BoFEP (Bay of Fundy Ecosystem Partnership), a virtual institute that is concerned with increasing cooperation among governments, communities, resource users and industries in development of sustainable futures for the communities and resources of the Bay of Fundy. Daborn has published 6 books on aquatic science, and more than 160 papers and reports.

Abstract

The concept of assimilative capacity is widely used in relation to fresh waters impacted by industrial, agricultural or domestic wastes to estimate how much waste can be passed into the environment. By definition, assimilation capacity is the "capacity of natural assets such as atmosphere, bodies of water, forests, to absorb pollutants within certain limits without detrimental effects"[1]. For centuries we have used the organic processing and dispersion capacities of estuaries and coastal waters to deal with organic wastes from domestic and industrial sources. As quantities of waste have increased, even these robust natural processes have been overwhelmed. Failure to recognize both the cumulative effects of multiple inputs, and the natural tendency of coastal waters to change, has led to serious degradation of many coastal ecosystems.

For several reasons, the idea of an assimilation capacity has rarely been applied to estuaries or coastal waters. Principal among these reasons are the greater complexity of estuaries and coastal waters than fresh water lakes and streams (where the concept is commonly employed), the multiple roles that such waters play, and the great variability in time and space that the basic biophysical processes of coastal ecosystems exhibit. Most of all, perhaps, it is the common but false assumption that the assimilative capacities of these ecosystems are very large, and therefore calculating them is unnecessary. This presentation outlines some of the limitations of the concept of assimilative capacity when applied to coastal receiving environments. We suggest that a combination of ecosystem modeling and continuous environmental monitoring would provide a basis for sustainably managing some wastes without compromising the many important roles that coastal ecosystems play.

Assimilative capacity of fresh waters.

The assimilative capacity of a river or lake is calculated to give a maximum value for the quantity of an effluent that should be allowed to enter the system. In the case of contaminants such as metals, pesticides or other industrial toxic materials, it is often a contaminant-specific calculation, based on knowledge of the sensitivity of particular organisms (especially fish) to that contaminant. The objective is to ensure that the focus organism does not achieve an unacceptably high 'body burden'. The assimilation capacity for organic wastes (generated by human residences, agriculture, aquaculture or industry), on the other hand, is commonly assessed according to the amount of oxygen that is needed for its breakdown by bacteria (i.e. Biological Oxygen Demand - BOD) or by chemical oxidation (Chemical Oxygen Demand - COD). In this case, the concentration of oxygen is the limiting factor: many highly valued species of vertebrates and non-vertebrates require oxygen levels to be above some limiting level (e.g. 50% of the saturation level) in order for them to survive. Since almost all organic matter can be oxidized under natural conditions (given sufficient time and availability of oxygen), the issue is not a level of contaminant in the receiving organism, but the general need of most organisms for a high level of oxygen in their environment. The critical factor is thus:

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[1] (Gilpin, Dictionary of Environmental and Sustainable Development, 1996).

"how quickly can the oxygen be replaced?" Re-oxygenation of fresh waters mostly depends on the amount of contact between the water and air[2]. Highly turbulent waters (such as riffle areas in streams, waterfalls, etc) quickly recover oxygen from the air to replace that consumed in the breakdown of the organic waste. Slow-moving, smooth-surfaced streams pick up oxygen much more slowly. Because of stratification[3], the deeper waters of lakes may be out of contact with air for months at a time, and thus cannot compensate for loss of oxygen from organic degradation. This leads to periodic winter-kill or summer-kill events in shallow, stratified lakes, especially if they have been enriched by nutrients or organic matter from human activities.

We have generally assumed that estuaries and coastal waters represent such large volumes of well-oxygenated and well-mixed water, or that exchange with the seemingly-infinite ocean is extensive, that we can safely dispose of much of our organic waste without problem. Unfortunately, that assumption is very often wrong.

The assimilative capacity for nutrients (e.g. nitrogen and phosphorus) is assessed as a level of input that will not quite trigger growth of unwanted algae in fresh water. The amount of nutrient that can be input depends upon a number of other factors: availability of light, rate at which the nutrients may be deposited in sediments, color of the water etc. There is plenty of experience in making these estimates for rivers, streams and lakes.

Characteristics of estuaries and coastal waters.

The difficulties of gauging the assimilative capacity of coastal waters arise from their great diversity and complexity. Coastal waters include bays and near-shore regions of the sea, which tend to have a consistently high salinity, and estuaries, in which sea water is diluted with fresh water from inflowing rivers. These environments represent some of the most biologically productive ecosystems known, yielding more useful food, for example, than most agricultural systems. Most important fisheries around the world are associated with the near-shore environment either in estuaries (e.g. the estuary and Gulf of St. Lawrence, the Bay of Fundy) or offshore banks such as Georges Bank and the Grand Banks. Although wild fisheries have declined, the lost production has been replaced by various forms of aquaculture in estuaries or embayments.

In addition to their high productivity, estuaries and other coastal environments serve a number of roles, including: spawning, feeding and nursery habitat for many fish, birds and marine mammals; trapping of materials flowing from the land and from rivers; processing of organic material derived from land or sea; and providing a pathway for migratory species between fresh water and ocean habitats. In recent years, plants and animals of coastal environments have also begun to serve as important sources of pharmaceutical products.

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[2] In lakes, much of the oxygen may be generated by photosynthesis, but this is usually a minor contribution in rivers.

[3] Formation of a layer of less dense water over a layer of more dense water, as in the warm surface layer in a lake in summer.

The critical feature of coastal receiving environments such as these is that they respond to all the changes in all the environments that interact at the coast: variations in the flow of rivers, changes to atmospheric conditions, and to the neighbouring land, for example. Even the seemingly unlimited ocean varies over short (e.g. tide) and long term (e.g. decadal oscillations of the North Atlantic sea level and mixing, pathway of the Gulf Stream, etc.) cycles, all of which may influence near-shore waters. The cumulative effects of human activities, in particular, have led to serious and often irreversible changes to these environments, to the detriment of the many important roles that coastal environments play.

Coastal receiving environments are very different from fresh water systems. One of the obvious differences is the high salinity of the oceans, which has numerous effects on the density of the water, on its ability to hold oxygen, and on the behaviour of non-living particulate material. In salt water, fine-grained sediments (e.g. silts and clays) flocculate, creating larger aggregate particles that tend to settle out rather than remain in suspension. Consequently, when such materials are introduced to the coastal environment, much will tend to accumulate in the near shore area. In estuaries in particular, flocculation often creates a highly turbid zone[4] in the innermost portions of the estuary where fresh and salt water first meet. High turbidity may limit light penetration into the water, and thus affect plant growth. Flocculation is often greatly enhanced by bacterial action, especially in coastal waters receiving large quantities of organic waste. Fine-grained sediments also tend to scavenge dissolved materials such as nutrients and contaminants, and cause them to be concentrated in the inner part of the estuary as well, instead of being dispersed to the sea. In general, estuaries act as very effective traps for sediments, nutrients and contaminants derived from the land or upstream.

Of all coastal receiving environments, estuaries are the most varied and changeable. The characteristic processes that affect their ability to assimilate waste, contaminants and nutrients from human society are strongly influenced by the ways in which fresh and salt water interact. Just how the two water masses mix depends upon the tidal range, the flow of the incoming river(s), the shape of the estuary, and its exposure to winds. At one extreme, where tidal exchange is high, and the flow of incoming fresh water is relatively small, tidal movements will cause almost complete mixing of the water. In such a *vertically mixed* condition, the salinity of the water is the same from top to bottom of the water column, and increases steadily as one moves from the river end to the sea. At the other extreme, where tidal influence is small compared with the flow out from the river[5], the lighter fresh water remains as a layer on top of the denser sea water all through the estuary. Consequently, salinity at the surface is about 0, and that near the bottom is about the same as the nearby sea. This *stratified* condition is similar to the state of a Canadian lake in summer time, and has at least one comparable effect: the lower layer of water has no direct contact with air, and is therefore prone to running out of oxygen, especially if organic loading is very high.

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[4] Known as the 'turbidity maximum'.

[5] In the Atlantic region, most examples of stratified estuaries are associated with dams and causeways built across the estuary, which limit the effects of tidal movement upstream.

There is a great variety of intermediate conditions between these two extremes, which results in each estuary being unique. Many Canadian estuaries shift from one extreme to the other during the year: they may be more or less stratified in spring when the snow melts and rivers are in high flow, or when tides are small, and then become more completely mixed in summer when rivers are very low and tides relatively dominant. This shift means that the ability of an estuary to handle nutrient or contaminant input is variable in time.

Another feature of coastal receiving environments (especially estuaries) that is a critical factor in assessing their assimilative capacity for handling our wastes is that they are often connected biologically with other coastal environments located at great distances. This connection is made by the migratory movements of fish, birds, and mammals. When we fail in our stewardship of our coastal environments, we compromise the biological resources that we share with other countries.

Waste processing mechanisms of estuaries and coastal waters.

The pattern of mixing, and the behaviour of sediments have much to do with determining the assimilative capacity of coastal ecosystems for organic and nutrient waste - the principal materials of concern in regard to fish processing plants. The accumulation of sediments in the near shore, especially in estuaries, means that adsorbed nutrients (attached to particulates) and organic matter also tend to concentrate near the point of release. Flocculation and absorption processes (incorporation into particulate matter) mean that materials may disperse far less than usually imagined.

Organic matter from sewage or industrial sources tends to become associated with other non-living sediments, and to be deposited or re-suspended with them. Because of the estuarine trapping mechanisms, organics tend to accumulate in near shore or inner estuarine areas, leading to depletion of oxygen as bacteria break down the organic matter. Whether the oxygen is replaced quickly enough depends upon wave action, tidal movements, and whether the system is stratified or well mixed. If the system is not well mixed, anaerobic conditions develop that may eliminate other important species such as shellfish or finfish. An oxygen-deficient region in the coastal environment can prevent normal migration from occurring. A moderate input of organic matter may end up facilitating the growth of some high value species such as bivalve shellfish that filter particles from the surrounding water. However, higher inputs are likely to create greater problems by eliminating species that require a well-oxygenated environment.

In contrast to fresh waters, marine and estuarine environments tend to be nitrogen-limited: i.e. the growth of plants is limited to the amount of nitrogen available, because the system traps and recycles phosphorus well, and nitrogen-fixing plants are not common in saline waters. When excess nitrogen is added, and there is sufficient light, plants will flourish. A common species that grows well under nutrient enriched conditions is *Ulva*; as this grows and dies, it has serious negative effects on the quality of the environment.

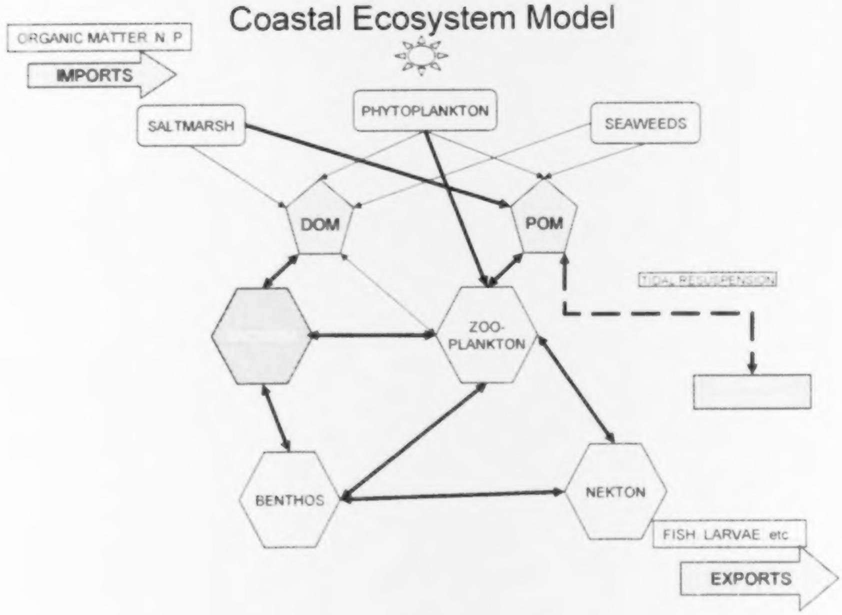
In summary, while many coastal systems have good mechanisms for processing organic matter and adsorbing excess nutrients, their capacity is finite. Much of that capacity depends upon the flushing rate of the coastal water, which is very often much less than people imagine. Since nutrients and organic materials can be quickly adsorbed by sediments, and these tend to be concentrated near shore, flushing rate calculations usually overestimate the capacity of the system to move materials away from the point of release. We have many examples where coastal systems have been overwhelmed by the inputs from industry or of domestic waste. This compromises the future of estuaries and coastal waters that we value for a wide array of reasons. It clearly makes no sense to treat them as simply waste processing systems.

Ecosystem models.

The processes underlying the productive capacity of estuaries and coastal waters are well known. Because of their complexity, however, and the highly varied and variable nature of coastal systems, estimation of the assimilative capacity requires construction of a specific ecosystem model: one that incorporates values and characteristics matching those of the particular ecosystem of concern.

Numerical models of ecosystem processes have been developed for many estuaries and coastal environments around the world. A simple model of this type is shown in the accompanying figure.

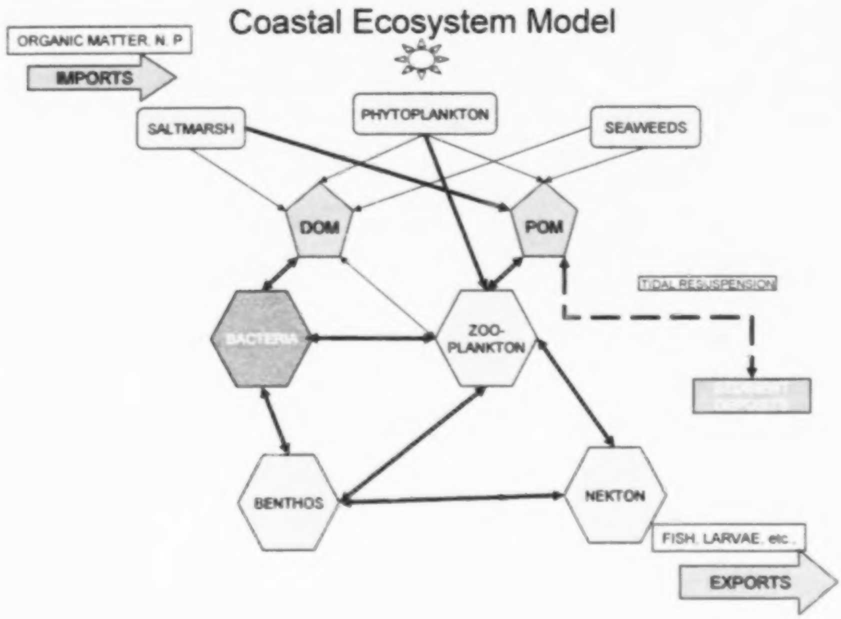
In almost all coastal waters, the main players are the same: plants fix sunlight and grow up to the limits set by the availability of required nutrients such as nitrogen and phosphorus. These plants provide the food for animals such as zooplankton (small animals in the water), nekton (larger swimming animals such as fish, jellyfish and crustaceans), and animals living on the bottom (the benthos). This pattern is similar to that in lakes and oceans; however, estuaries and coastal waters differ in several respects. Some of the production of these plants forms the dissolved organic matter (DOM), which is taken up by bacteria. Much of the remaining organic matter produced by plants, or brought in from the land and rivers, becomes non-living particulate organic matter (POM), and becomes food for animals in that form rather than as green, living plants. Consequently, bacteria, which are often associated with sediment surfaces, are an extremely important link in the food chain. In breaking down the organic matter, bacteria require oxygen. Excessive input of organics or of nutrients that stimulate more plant growth therefore leads to an overabundance of organic matter. This in turn overloads the natural capacity of bacteria in the system to break down and results in greater and greater oxygen depletion. How quickly the oxygen is replaced, depends upon such things as waves, tidal movements, temperature etc.


Coastal Ecosystem Model
ORGANIC MATTER N P
IMPORTS
SALTMARSH
PHYTOPLANKTON
SEAWEEDS
DOM
POM
TIDAL RESUSPENSION
ZOO-PLANKTON
BENTHOS
NEKTON
FISH LARVAE etc
EXPORTS

Assessing the assimilation capacity of coastal receiving environments.

Estimating the assimilative capacity of any Canadian coastal water requires an ecosystem model that must be significantly modified from those developed for US or European systems. Our variable temperatures, tidal movements, and extensive ice formation in winter create conditions that are often markedly different from those for which most ecosystem models have been developed.

Creating an appropriate model requires specific and extensive environmental data from the system of concern: knowledge of the hydrodynamics, sediments, and local climatic conditions, and of the principal biological components. Since all these things vary over time, even in the absence of human interference, a long term data set is needed to create and verify the numerical model that could be used for estimating the assimilative capacity of the system.


Coastal Ecosystem Model
ORGANIC MATTER, N, P
IMPORTS
SALTMARSH
PHYTOPLANKTON
SEAWEEDS
DOM
POM
TIDAL RESUSPENSION
BACTERIA
ZOO-
PLANKTON
BENTHOS
NEKTON
FISH, LARVAE, etc.
EXPORTS

Assessing the assimilation capacity of coastal receiving environments.

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Scientists with government agencies such as DFO and NRCan, and at regional universities, have the ability and experience to create such models[6]. To verify them requires continuous monitoring of the various factors (hydrodynamic, biological, chemical, climatic etc.) that control the changing processes that characterize the coastal environment. What is also needed, therefore, is a good collaborative relationship with those whose wastes need to be accommodated: industries, municipalities (etc.), who are in the best position to conduct continuous monitoring activities.

The knowledge is available or can be obtained. There is really no excuse for continued degradation of our valuable coastal environments.

A final consideration is: who should decide what the objectives of estimating the assimilative capacity of a given coastal environment should be? It is not just a question of scientific criteria. Since all our coastal ecosystems provide several different services for humans (sources of food, minerals, pharmaceuticals, transportation, waste disposal, and tourism, for example), there are inevitable conflicts over the desired state of the environment. It is a social issue, not just a matter of minimizing costs for a local industry. From this perspective, the parameters of assimilative capacity have to be resolved to satisfy the needs of the whole community.

"Fix the problem – not the blame"
Graham Daborn, February 2003

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3.11 Considerations in ocean outfall design. Jochen Schroer, M.Eng., P.Eng., NATECH Environmental Services Inc.

Biographical Sketch

Jochen Schroer, M.Eng. P.Eng. is president of NATECH Environmental Services Inc. Jochen has more than 10 years of professional experience in environmental engineering, much of that in the assessment and management of effluents in estuarine water bodies. Jochen holds a B.Sc. degree from Germany and a Master's degree from UNB. In New Brunswick, Jochen carried out effluent dispersion studies for several coastal water bodies, including Lamèque Bay, Shippagan Harbour, Néguac Bay, the Miramichi Estuary and the Saint John River Estuary.

NATECH specializes in the design of sewage treatment plants and the prediction of effluent behaviour in receiving water bodies. The company uses numerical models to simulate the hydrodynamic conditions in rivers and estuaries and superimposes water quality processes (mainly dispersion and decay) onto water currents. The model simulations allow for predictions of effluent plume behaviour and for the optimization of outfalls. The models take the surrounding environmental conditions into consideration.

Abstract

In most cases, the necessity exists for effluent discharge into receiving waters, even after wastewater treatment at source is implemented. Also, even with treatment, the effluent quality is not likely to match natural background levels of the receiving water. Therefore, a potential for impacts on other resource users or ecosystem components in the vicinity of the outfall remains. To minimize impacts, an outfall should be designed to meet specific criteria. Design of effluent dispersion facilities requires an understanding of:

- Effluent characteristics in terms of flows and composition (organics, solids, nutrients, micro-organisms, etc.) and their variations.
- Resource characteristics and resource uses or "valued ecosystem components" (ecosystems, human activities).

- Receiving water characteristics (movement, transport and removal processes).
- Physical mixing processes.
- Economics of installing structures under water and in areas affected by ice, scour, sediment transport and wave action.

Effluent dispersion is characterized by near- and far-field processes. In the near-field, when an effluent leaves the discharge pipe it usually has a higher velocity, relative to the receiving water. This difference results in shear stress with the receiving water and this, in turn, causes turbulent mixing. Receiving water mixing with the effluent provides an initial dilution and this turbulent mixing continues until the energy in the discharge is dissipated, and the velocity of the plume matches that of the receiving water. In addition to a velocity differential with the receiving water, most effluents have a different density than the receiving water. The effluent is typically less dense (often due to being warmer or less saline) and therefore tends to rise in the water column. This results in another shear stress, similar to that resulting from the velocity differential. In the far-field, after the initial dilution stage, the effluent plume typically moves horizontally, borne by the velocity of the receiving water. The nature of subsequent dilution and dispersion is specific to the type of receiving environment and climatic conditions. Buoyant spreading of the plume and passive diffusion are the predominant factors leading to far-field effluent mixing. Figures 1 and 2 illustrate the mixing processes from a single pipe outfall.

To maximize mixing near the outfall, designers try to increase the shear stress between the effluent and the ambient fluid. This can be achieved by adjusting the outfall depth, pipe opening alignments, number of pipe openings, etc. An outfall with several openings is referred to as a diffuser. Different diffuser configurations are illustrated in Figures 3 and 4.

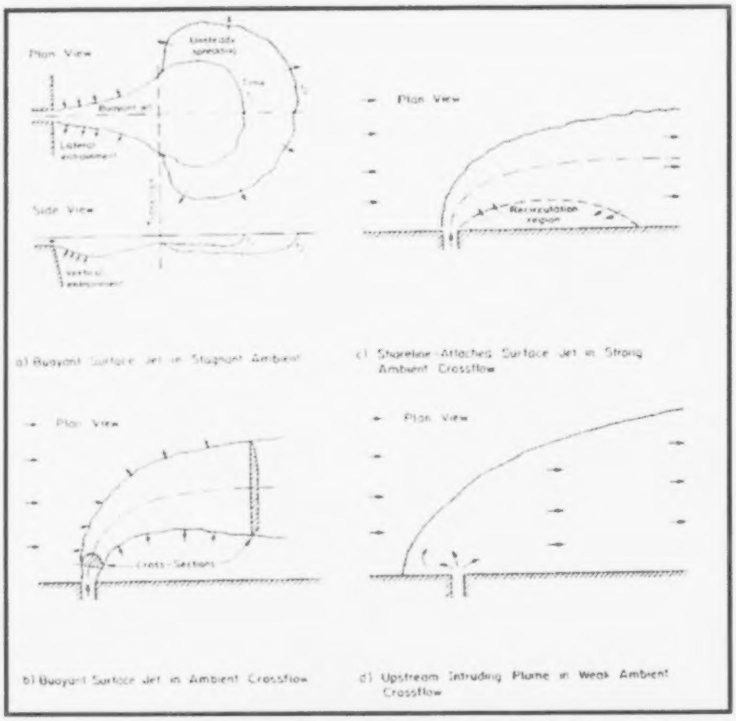
Plan View
Unsteady spreading
Buoyant jet
Lateral entrainment
Side View
Vertical entrainment
a) Buoyant Surface Jet in Stagnant Ambient
Plan View
Recirculation region
c) Shoreline-Attached Surface Jet in Strong Ambient Crossflow
Plan View
Cross-Sections
b) Buoyant Surface Jet in Ambient Crossflow
Plan View
d) Upstream Intruding Plume in Weak Ambient Crossflow

Figure 1. Plan View of Single Pipe Outfalls

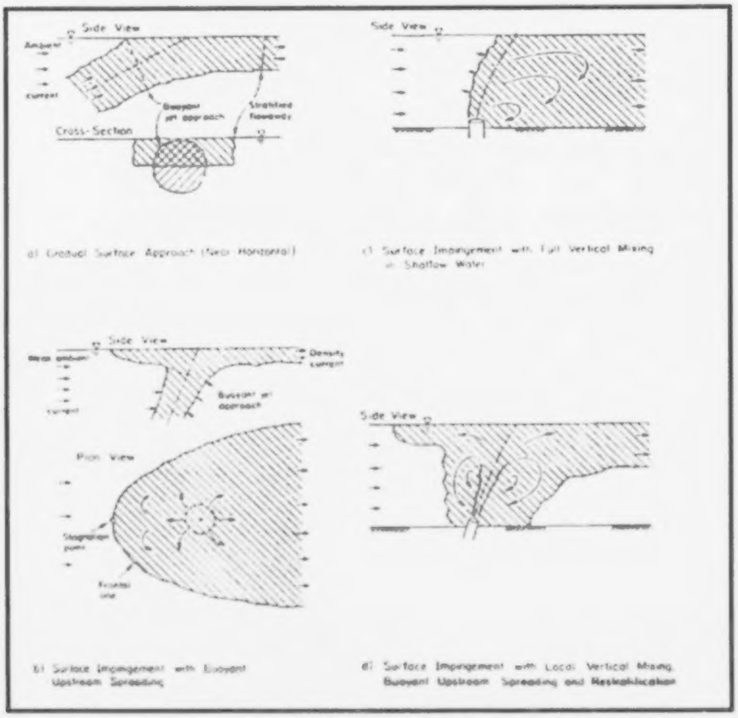
Side View
Ambient
current
Buoyant jet approach
Stratified flowaway
Cross-Section
a) Gradual Surface Approach (Near Horizontal)
Side View
c) Surface Impingement with Full Vertical Mixing in Shallow Water
Side View
Weak ambient
current
Density current
Buoyant jet approach
Plan View
Stagnation point
Frontal line
b) Surface Impingement with Buoyant Upstream Spreading
Side View
d) Surface Impingement with Local Vertical Mixing, Buoyant Upstream Spreading and Restratification

Figure 2. Side View of Single Pipe Outfalls

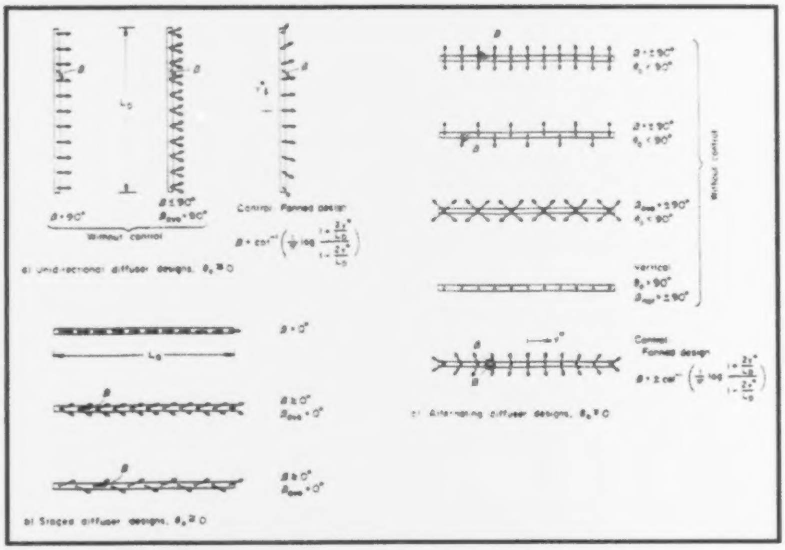
Without control
Control: Fanned design
a) Unidirectional diffuser designs
b) Staged diffuser designs
c) Alternating diffuser designs
Vertical
Without control

Figure 3. Commonly Used Diffuser Configurations
Source: Adapted from H. Jirka, 1996

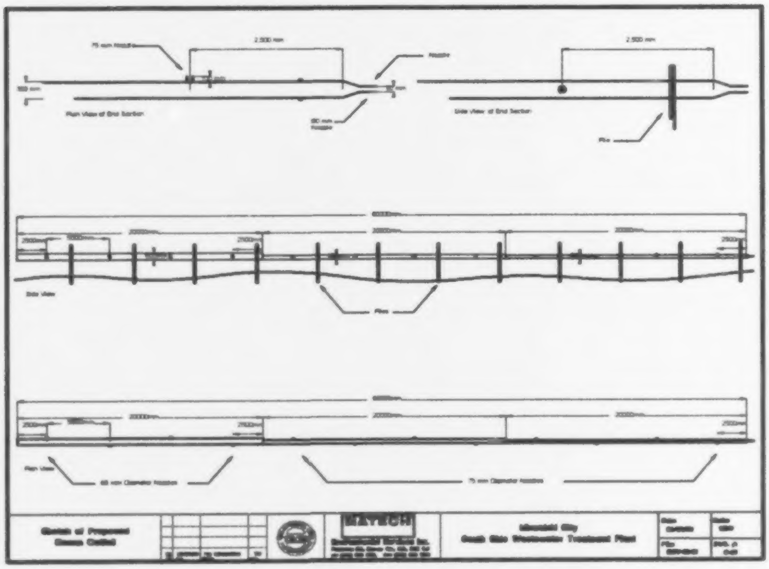
Plan View of End Section
Side View of End Section
Side View
Plan View

Figure 4. Site Specific Diffuser Design

General outfall design procedures include:

- Select the preferred general outfall location, assisted by hydrodynamic modeling.
- Determine the valued ecosystem components in the area.
- Determine the required setbacks to avoid impact.
- Design an outfall that provides effluent mixing to acceptable levels within the available space and under economic considerations.

Panel discussion on receiving environment applications

Moderator: Andy Woyewoda (NRC-IRAP)

Panel Members: Speakers

The first question from the audience had to do with the dispersion modelling by Jochen Schroer in the Lamèque Harbour area and what effect, if any, the placement of the bridge and its causeway approaches have had on flushing? Based on his studies Jochen believes there is little reduction in flushing.

Thierry Chopin was asked to expand on his statement that outfall location is probably of no real consequence within the harbour because of the limited flushing overall within that enclosed environment. He said that this is apparently the case but while moving the outfall to another location within the harbour may not provide any relief, maybe going somewhat outside the harbour with the outfall would provide an advantage.

Inka Milewski added a cautionary note: comments in her presentation that Bouctouche is bad but not as bad as Lamèque, were taken out of context by media. Therefore we should be careful in accepting Graham's statement that estuaries are good treatment systems for organics; there is clearly a limit to this capacity but the public and the media may not make this distinction. Graham agreed that in the Atlantic region nutrient loading has already exceeded the assimilative capacity of the receiving environments in many cases. Assimilative capacity is not the same as the maximum amount that the system can absorb and degrade because this maximum will have consequences regardless in terms of community structure, species diversity and other ecological factors of importance to a stable environment. He expressed the view, contrary to what Jochen had said, that the bridge opening in Lamèque might be improved to increase the flow through. Thierry added that we need to improve our ability to avoid areas where there is limited flushing for outfalls.

Another participant wanted to know more about the possibilities of applying Thierry's ideas to the situation in Lamèque in order to use the *Ulva* (sea lettuce) in some manner. Thierry answered that *Ulva* is a simple alga (much like an efficient solar panel with two layers of cells) which, moreover, can grow asexually when it breaks off and that is why it is so successful there. There are few applications for *Ulva* commercially, especially if harvested on the beach mixed with sand and dirt. *Laminaria* was chosen in the Bay of Fundy because it grows best in winter. Different conditions dictate that different species be used. But in general it isn't clear what polyculture, or integrated aquaculture, scheme could work as part of the fish processing plant effluent treatment along this coast because of the nature of the effluents, and the problem with ice cover in winter, a condition that doesn't generally exist in the Bay of Fundy where his work has taken place. Use of artificial wetlands also works better in warmer climates.

Mike Chadwick noted that the situation in a place like Lamèque may not be comparable to the situation in Brittany. In the case of Brittany, Thierry had suggested that the nutrient contamination in sediments had built up over years and would not go away immediately with abatement alone. In Lamèque, on the other hand, there has not been such a long history of nutrient enrichment and therefore the recovery phase might not be so protracted. He wondered if Thierry had other examples where this latter case exists? Thierry repeated that green tides in Brittany are related to agricultural practices (intensive pig and cattle farming) over the last few decades. The situation in Lamèque is also an *Ulva* problem. This species will be there for years to come, drawing upon nutrient reserves in the sediments.

Inka Milewski added that relocating the pipe may not work if there is no improvement in discharge, even though the model may show that there would be an improvement. She agreed that this is a problem decades in the making and these sediments have a heavy load of contaminants that needs to be neutralised in some manner. So the problem with *Ulva* will go on. H_2S is as much as 2 ft. (0.6m) deep in the sediments. Graham also agreed that the relocation of the pipe a couple of hundred metres will only increase the growing zone of *Ulva*.

A recommendation came from the floor that in the lack of scientific data on problems of this kind, where they have seen thousands of fish dead and have had human health warnings issued, why not enforce a zero discharge situation at the plant in Lamèque. This could serve as a pilot project and observe the effect in terms of recovery of the environment. Graham agreed that we don't have good case studies at the moment and making Lamèque Bay a test site might be worth considering.

4.0 BUILDING A PLAN

What can we do now and in the future?

This part of the workshop agenda took the form of a panel discussion including a number of speakers from earlier sessions and a select number of additional commentators. Each panel member was accorded the opportunity to make a few opening remarks and these are briefly reported along with a digest of the thoughts coming from both the panel and the floor.

Panel discussion: Directions and mechanisms to move forward.

Moderator: Simon Courtenay (DFO)

Panel Members:

- **Andy Woyewoda (NRC-IRAP)**
- **Mike Chadwick (DFO-Moncton)**
- **George Lindsay (EC-Fredericton)**
- **Lise Ouellette (UdeM-Shippagan)**
- **Sylvain Poirier (MPRDC-Shippagan)**
- **Harry Collins (sGSL Coalition on Sustainability-Moncton)**
- **Angélina Cool (N.B. Seafood Processors Association-Moncton)**
- **Louis Arsenault (NBDAFA-Fredericton)**

As moderator for this panel, Simon Courtenay summarised where we seem to be headed based on discussions so far. What we do now is bring together the final products of this workshop:

- A report on the presentations and discussions
- Pilot projects
- Other products
- Networks

We should be looking at fish plants generally, in a positive manner, leading to general improvements, rather than focussing on specific sites.

Each panel member was invited to give a brief statement on where they thought we should be headed.

Sylvain Poirier:
This is a very complex issue we are faced with and we are here to move the agenda forward. One thing that needs emphasis is the possibility of recovering organic matter to minimise waste and improve product utilisation. In this regard, there is a demonstrated need for coagulants that are safe for consumption. There needs to be more research in this area to ensure that these work with many different effluent types. The Marine Products Research and Development Centre (MPRDC) has done some research into this, but we know that there is much more to be done. Value-added products like bait, aquaculture diets, etc. are also worth exploring. A partnership with industry is needed to earn their confidence so that they will share information with others working to resolve this problem. From all the presentations we have heard, there is no one individual who had all the answers, so we need to work together to find solutions. We are at the beginning of

this exercise and need to develop a core of expertise in this area and look at innovative approaches to deal with the problem. The MPRDC recently obtained funding to do research on herring. There they will bring together all the people from the industry from capture, to transport, to processing, to use or disposal of residues. The objective is to maintain quality from beginning to end, resulting in better product recovery and reduced pollution.

Angélina Cool:
The New Brunswick Seafood Processors Association recognises the need to develop research partnerships or associations because they don't have the capacity in their organisation to undertake this work alone. There is also a need to look at the seasonal aspects of this industry more carefully in terms of the kinds of control applications that are suitable. We need to learn how to make use of all ingredients and recover more of the raw material to be incorporated into products through improved systems. One idea that emerged from the presentation by José Molina may have prospects for consideration here in this region -- the idea from Chile where one treatment system served many plants. Finally, she stressed once again that national standards and regulatory controls for the seafood processing industry are needed, rather than singling out one region, and that this also implies the need for research to be undertaken at the national level.

Louis Arsenault:
Louis remarked that it had been an interesting two days, but the goal now is to determine where to go from here and how to keep up the momentum. Industry will continue to evolve and diversify and consolidate, so we can expect the need for new solutions all the time. We are working with a natural resource and should always keep in mind ways of making optimal use of that resource. One idea not mentioned so far is that cook water could be beneficially utilised. Japanese companies that make surimi need flavours for their products and these can be extracted from cook water. It is truly hard to understand why Canada wastes this valuable resource. The answer seems to be that finding solutions like these requires a team approach.

Harry Collins:
As a representative of the Southern Gulf of St. Lawrence Coalition for Sustainability, Harry noted the importance of involving the local communities in whatever process follows this workshop. Also, he noted that the southern Gulf of St. Lawrence could serve as a mesocosm in which to test solutions that will have broader applicability in Canada and around the world. Real solutions can only come from the community level. The communities are the foot-soldiers who will be there at all times when needed. These organisations represent all the local stakeholders, including industry. The "Enviro-club" model in Québec and N.S. may be a good model to introduce here. ACOA is prepared to work with and fund the activities of these organisations. Also, DFO and EC need to look at the multiple sources of nutrient pollution in a more general way and other provinces need to be involved as well. If we can get ACOA and NRC on the team to provide resources and expertise that would be beneficial

Mike Chadwick:
The real fear now is that tomorrow this will slip off the agenda again as it has before. We need to keep up the momentum. We need to look at home-grown solutions. This is a real example of Integrated Coastal Zone Management (ICZM) in a practical and non-academic application. It's a big problem, as alluded to by Jeffrey Corkum and Inka Milewski, but we really don't know how big a problem it is until we start studying the situation at the local scale. We also need to make better use of the facilities at the University of Moncton Shippagan Campus and its associated research and development centres in practical as they can contribute to aspects of coastal management. One area in which we require a good deal more research is in understanding the physical forcing functions. All this will help us to prioritise our efforts. Monitoring for ecosystem health needs to be undertaken on a regular basis and we can do this with our own local resources. The bottom line is that DFO is ready and willing to help.

George Lindsay:
George had no disagreement with anything that others have said, but there were a couple more points to be added on the regulatory side. Existing guidelines under the *Canada Fisheries Act* are only covering a small aspect of the problem, primarily the screening of large particulates. So Jeffrey Corkum's study characterising fish plants across Atlantic Canada will take us on to a clearer understanding of the dimensions of the problems, which will lead us to some possible solutions. Pollution Prevention (P2) programmes are the best way to start going on from where the Guidelines leave off, working inside the plant improving water conservation and waste segregation, finding ways to provide better product handling and better use of waste streams for value-added. All this has to be done on a plant-by-plant basis. The industry needs to accept this and co-operate and so does the community. Harry Collins spoke of the example in the Miramichi of a community-based organisation developing an environmental management plan that covered all pollution sources in the region. Perhaps this is a model that could be tried elsewhere. After taking care of the basic elements of pollution control, there is a world of opportunity in the area of by-product recovery and more sophisticated biological treatment regimes. Beyond that however, it must be recognised that in due course we will be compelled to look at the regulatory regime.

Andy Woyewoda:
Andy observed that it is a crooked path we are walking down with many twists and turns. Paul Bourke had noted that this is an international problem and that is true, but while we can make use of the experiences gained elsewhere, we still have to find solutions to locally unique situations. He expressed concern with the idea of simply putting an effluent pipe out into a more active mixing zone and then forgetting about it until a solution comes along. That being said, we have to recognise that a company must make money in the end and they often don't have excess profit to bring to bear unless there is an immediate payback, either in terms of making more money down the road or simply staying in business. At the least, they want to know that the improvements they achieve are worthwhile in terms of environmental improvement. If forced to spend too much, a reasoned business case will require that they move or else they will go out of business. So we have to ask ourselves what is a reasonable and responsible "target" that these

companies should be challenged to achieve. And of course this has to take into account variables such as the assimilative capacity and the local micro-environment. Technologies we have heard about haven't been tested on seafood plant effluents for the most part. So this seems to be the next logical step to take as a group. Pipe extensions may or may not be worth considering. Other sources of pollution mean that this has to be done via a round table approach with all those involved who share in the problem. There is money available to apply to this problem but it must be through a concerted effort.

Lise Ouellette:
The organisers are to be congratulated for bringing together these many stakeholders. This is a success in itself. An integrated approach is essential to resolving complex problems such as these. As Mike Chadwick has already said, a practical form of ICZM is the best model to follow. The fishing industry needs to improve its environmental performance because of the major role that it plays in our economy and in our coastal communities. This puts a great responsibility on the industry. Rural Atlantic communities have always made their living from natural resources and we must ensure that these resources are being managed in a sustainable manner. We need to protect areas like Miscou, which is a small local treasure. Coexistence of different users needs to be considered -- co-operation is needed. Economic activity coming into the area must be viewed as positive and in order for this to be so we need to be able to control their effects on the environment in a cumulative sense.

In terms of deciding how and where to undertake pilot projects, Lise felt that we should avoid creating the perception that we are in effect rewarding companies whose activities have caused the greatest problems. Instead the pilots should be undertaken with the companies that have demonstrated the greatest understanding of the problem and the greatest willingness to work toward solutions. One way of ensuring this would be to hold a competition for the pilot project(s) where funding would be provided to the successful proposal and would reward those who present the best plan and who are prepared to put the most into the pilot themselves. The idea of establishing a number of working groups to carry on this effort recommends itself. At this juncture we should ask ourselves "What do we need to do to get these working groups going?" Does this require the traditional "carrot and stick" approach, for example? What is the optimal geographic scale to be working within, considering concerns heard from many that the industry relies on the same international markets as all other fish plants across the country and cannot alter their economic circumstance without impacting their competitiveness? Whatever path is chosen, we must always keep in mind the benefits of following an integrated approach.

At this point the moderator threw open the floor for comments, observations and questions from the assembled participants.

The first speaker provided two comments. First, the session has been very informative and something like this should perhaps be the subject of an educational programme. We can conclude from what we have heard that the problem in Lamèque will not be gone next year no matter what measures are taken. But the public needs to be educated to the reality that this is the case even though everyone is doing the best they can to work toward solutions. Secondly, we need to recover and not bury the sludge from fish plants as much as possible so that it doesn't simply add to the existing problem.

Sylvain Poirier responded that the issue of recovery for food production or other by-products is being researched and will be the topic of further research at the MPRDC and elsewhere. Andy Woyewoda added that some of the other technologies discussed also produce sludge that can be converted into edible products.

Another speaker reiterated that this is an integrated problem that demands an integrated solution. None of the technologies seen will solve 100% of the problem. So we need a more integrated approach involving several methodologies. One thing that is surprising is the lack of information on what comes out the end of the pipe. Most of what we know seems to be based on 1970s data. The province's new requirement to sample every year is a good start but it must be done rigorously. Sample collection and analysis shouldn't be managed by industry as this would place them in the difficult situation of having to provide data that might potentially lead to charges or fines. Rather, the programme should be run independently as an opportunity to provide accurate and useful up-to-date information that can be shared anonymously to provide better synoptic comprehension of the overall state of the industry. This presents a bit of a selling job for the regulators in order to encourage industry support for such a system. The idea that Paul Bourke brought up of a working group that can meet regularly and fight with one another, but eventually learn to co-operate in finding solutions holds great promise locally. There are also some other academics who work in the field but who were not present and we need to involve theses as well.

The moderator reiterated that Mike Chadwick has committed DFO to whatever follow-up emerges naturally from this workshop. In regard to monitoring, both DFO and EC as well as the academic community can guide monitoring by suggesting the "what and how".

Another participant felt that there needed to be a group of experts established to look into potential peat moss applications. Sylvain mentioned that there was a consultation with seafood processors in the Fall of 2001 and that the need for research on seafood processing plant effluents was prioritised. At the time, the participants did not know that researchers at the MPRDC were already working on this issue along with some members of the industry. He remarked that some of this experimental work needs to be done in the off-season to avoid disruption of the plant operations. Otherwise it can be done on a small pilot scale off-line – a sort of mini-laboratory. They are presently trying to find funding to pursue their ideas on integrated approaches to improving plant effluents.

A representative of the concerned citizens of Lamèque pointed out that they had been working on the problem with odour in Lamèque since 1995. In reality the source of that problem has been there for 25 years. He argued that Mike Chadwick had noted that this is just the beginning of a solution finding process, but for them it is getting close to the end. They cannot put up with this for any longer. They argue that we need to take action now and study the results afterwards to find out what works best. The silver bullet is money. It cannot take another 20 years to clean up this problem. It cannot wait any longer. Air pollution in Lamèque is among the worst in Canada – this is unheard of in such a small rural community.

Andy Woyewoda responded that if you have a lot of money available the Epsilon system might work. But the sea lettuce may also have to be physically removed. He agreed that there are things that can be tried. The Zenon system (a reverse osmosis membrane system) could cure the problem, for example – but at great expense.

Others regretted that no one was here to speak about the human health effects in Lamèque.

Mike Chadwick said it was important to hear such points of view and concerns but that it is essential that we make full use of our time together to get on with finding the best route forward. We have become more aware of the issues and the potential solutions. We are also aware of the resources already being brought to bear. The question of where and how a pilot project should take place must be considered. People needed to achieve dialogue that could result in solutions and this opportunity should be seized. We've dealt with some very difficult issues and done so in a civil and positive manner.

5.0 CONCLUSIONS

The way ahead

This Section briefly summarises the results of the workshop as outlined by Mike Chadwick on behalf of the co-champions. Although this part of the agenda was originally intended to have been a panel discussion with the co-champions leading discussion and taking ideas from the floor, the co-champions were able to gather these ideas for presentation in advance. They used this time to build a team or working group of volunteers to carry on with the work after the workshop's conclusion.

Three things stand out as being essential if we are to carry on the significant progress begun by this workshop.

First we must put in motion a working group, rather than the more formal task force as Paul Bourke had suggested. The geographic focus would be the Gulf shore of New Brunswick. Industry, regulatory organisations, academic and research bodies, communities and environmental NGOs should all be invited to participate. The motivator can be the *Canada Fisheries Act*, though that would be the heavy-handed approach and the interest and concern demonstrated by those representing the industry at this workshop also indicate that such an approach is not needed. On the other hand, we do need a meaningful time frame to sharpen the interest of everyone involved in the problem. We should also look at the scale of the problem from the point of view of sources to be contained and controlled; for example it seems evident that we should also be looking at including the effluent from fishing vessels as an issue to be addressed.

The second concept that should be pursued in tandem with the first is promoting basic best management practices (BMP) and pollution prevention (P2) in fish plants. There are many techniques that can and should be pursued right away. At the moment we don't have guidelines for New Brunswick like those produced in British Columbia by the Fraser River Action Plan (FRAP), but we could borrow ideas from what has already been done there and elsewhere. An important part of this is that the plant workers and supervisors need to be educated to the benefits in instituting and adhering to such procedures. Ultimately it may be worthwhile to make these guidelines part of the approval to operate, but they will be better and more effective if they are adopted voluntarily by the industry as a whole.

The third idea that emerged from the workshop is the concept of instituting a pilot project or a series of pilot projects. This is needed because of the complexity of effluent streams in the many kinds of fish plants and process lines employed in New Brunswick. The techniques like the Epsilon technique and the MPRDC technique need to be tested and proven in realistic circumstances before being implemented at full scale. Ultimately it may be useful to consider building on the existing capacity at the University of Moncton at Shippagan and associated organisations like the Marine Product Research and Development Centre to create a permanent test laboratory like the ice centre at Memorial University in St. John's, Newfoundland.

Before the meeting adjourned, names were taken of those interested in participating in the proposed working group. This ensured the continuity of the process and was soon followed by the first teleconference to fill out the membership and the first meeting of the working group in Miramichi, New Brunswick in April, 2003.

> NOTE: Although this workshop was intended to be a general examination of the overall subject of fish plant effluents, their control, utilization and effects on the environment, it was perhaps inevitable considering the venue of the workshop for some hopes to have been raised that the specific and critical problems facing the residents of Lamèque would form a part of the discussions and conclusions. When this was found not to be the case, a number of residents expressed their bitterness at the outcome. The Chairman of this session, Mike Chadwick, reminded the meeting of the general nature of the dialogue in this case, but committed to work with residents and stakeholders to move toward a solution to the problems in that community. This initiative, though separate from the process outlined in the Conclusions Section, should draw extensively from the lessons learned in that process

APPENDICES

Appendix A: List of Participants

Bernard Albert, Industrial Technology Advisor
Industrial Research Assistance Program
National Research Council of Canada (NRC)
275 Main St., Suite 212-I
Bathurst, N.B. E2A 1A9
Tel.: (506) 549-5220
Fax: (506) 549-5221
Email: bernard.albert@nrc-cnrc.gc.ca

Florence Albert, Executive Director
Professional Shellfish Growers Association of New Brunswick
220 St. Pierre Ouest Boul., Office 210,
Caraquet, N.B. E1W 1A5
Tel.: (506)727-0886
Fax: (506)727-5286
Email: Aqua@nb.aibn.com

Louis Arsenault, Director
Commercial Fisheries Development Branch
New Brunswick Department of Agriculture, Fisheries and Aquaculture
P.O. Box 6000
Fredericton, N.B. E3B 5H1
Tel.: (506) 453-2252
Fax: (506) 462-5929
Email: louis.arsenault@gnb.ca

Brian Blanchard
Scotian Halibut Ltd.
25 Kenney St.
Clark's Harbour, N.S. B0W 1P0
Tel.: (902) 745-0180
Email: brianblanchard@klis.com

Paul Bourke, Manager
Trident Seafoods Ltd.
5303 Shilshole Ave., NW
Seattle, Washington 98107-4000
USA
Tel.: (206) 783-3818
Fax: (206) 782-7195
Email: paulbourke@tridentseafoods.com

Paul F. Chiasson, President
S.O.S. Baie de Lamèque
58 rue Principale
Lamèque, N.B. E8T 1M6
Tel.: (506) 344-7498
Email: www.sosbaiedelameque.com

Dr. Thierry Chopin, Chair
Department of Biology
Centre for Coastal Studies and Aquaculture (CCSA)
Centre for Environmental and Molecular Algal Research (CEMAR)
University of New Brunswick (Saint John Campus)
P.O. Box 5050
Saint John, N.B. E2L 4L5
Tel.: (506) 648-5507
Fax: (506) 648-5811
Email: tchopin@unbsj.ca

Harry Collins
Miramichi River Environmental Assessment Committee (MREAC)
133 Newcastle Blvd.
Miramichi, N.B. E1V 2L9
Tel.: (506) 778-8591
Fax: (506) 773-9755
Email: mreac@nbnet.nb.ca

Ms. Angélina Cool, Executive Director
New Brunswick Seafood Processors Association
1133 St. George Blvd., Suite 420
Moncton, N.B. E1E 4E1
Tel.: (506) 857-3056
Fax: (506) 857-3059
Email: nbspa@cme-mec.ca

Jeffrey Corkum, A/Head Pollution Control
Environment Canada
16th Floor, Queens Square
45 Alderney Drive
Dartmouth, N.S. B2Y 2N6
Tel.: (902) 426-8926
Fax: (902) 426-3897
Email: jeffrey.corkum@ec.gc.ca

Dr. Graham R. Daborn, Director
Acadia Centre for Estuarine Research
Acadia University
P.O. Box 115
Wolfville, N.S. BOP 1XO
Tel.: (902) 585-1113
Fax: (902) 585-1054
Email: graham.daborn@acadiau.ca

Dr. Jean-Yves Daigle, Director General
Peat Research and Development Centre Inc.
218, boul. J.-D.-Gauthier
Shippagan, N.B. E85 1P6
Tel.: (506) 336-9719
Fax.: (506) 336-0302
Email: jydaigle@cus.ca

Mrs Jessie Davies, Director
Environment and Sustainable Development Research Centre
University of New Brunswick (Fredericton Campus)
P.O. Box 4400,
Old Arts Building, Room 211
Fredericton, NB E3B 5A3
Tel.: (506)453-4886
Fax: (506)453-4883
Email: jdavies@unb.ca

Nathalie S. Delagarde, Coordinator
S.O.S. Baie de Lamèque, Inc.
18 rue du Pêcheur
Lamèque N.B. E8T 1L1
Tel. : (506) 344-5893
Fax : (506) 336-1415

Marcel Duguay, Production Manager
Island Fishermen Cooperative Association Ltd.
90 rue Principale
Lamèque, N.B. E8T 1M8
Tel.: (506) 344-2204
Fax: (506) 344-0413
Email: acpi@nb.aira.com

Ron Fougère
Paturel International
P.O. Box 99
Cap-Pelé, N.B. E0A 1J0
Fax: (506) 533-1233

Paul Fournier, Regional Director
N.B. Environment and Local Government
159 rue Main St., Suite 202
Bathurst, N.B. E2A 1A9
Tel.: (506) 547-2092
Fax: (506) 547-7655
Email: paul.fournier@gnb.ca

Graham Gagnon
Dept. of Civil Engineering
Dalhousie University
Sexton Campus, Room D215
1360 Barrington Street
Halifax, N.S. B3J 1Z1
Tel.: (902) 494-3241
Fax: (902) 494-3108
Email: graham.gagnon@dal.ca

Bertin Gauvin, General Director
Coalition for the Viability of the Environment of Shippagan and the Islands of Lamèque and Miscou
28 rue de l'Hôpital
Lamèque, N.B. E8T 1C3
Tel.: (506) 344-3222
Fax: (506) 344-3266
Email: comite.havre@nb.aibn.com

Nadine Gauvin
Shediac Bay Watershed Association
164 Pleasant St., Suite A
Shediac, N.B. E4P 2L8
Tel: (506) 533-8880
Fax: (506) 533-7880
Email: sbwa@nbnet.nb.ca

David Giddens
Connors Brothers
669 Main Street
Blacks Harbour, N.B. E5H 1K1
Tel.: (506) 456-1233
Fax: (506) 456 1553

Cynthia Gillis
OCL Group
47 North St.
Dartmouth, N.S. B2Y 1B7
Tel.: (902) 463-0114
Fax : (902) 466-5743
Email : ocl@accesscable.net

Charles Goguen, Commercial Fisheries Development Officer
N.B. Department of Agriculture, Fisheries and Aquaculture
26 Acadie Street,
Bouctouche, N. B. E4S 2T2
Tel.: (506) 743-7222
Fax: (506) 743-7229
Email: charles.goguen@gnb.ca

Mauricio González, Biochemist
Marine Products Research and Development Centre Inc. (Shippagan)
218, boulevard J.-D.-Gauthier
Shippagan N.B. E8S 1P6
Tel.: (506) 336-9618
Fax: (506) 336-0321
Email: gonzalez@umcs.ca

Fleur-Ange Haché, Secretary
S.O.S. Baie de Lamèque, Inc.
26, rue du Rivage
Lamèque N.B. E8T 1L5
Tel. : (506) 344-7368

Linda Haché, Project Leader
Employment Development
Community College of New Brunswick (Shippagan Campus)
218, boul. J.-D. Gauthier
Shippagan, N.B. E8S 1P6
Tel.: (506) 726-2527
Fax: (506) 726-2414
Email: linda.hache@gnb.ca

George Haines, Assistant Deputy Minister
Environmental Management Division
New Brunswick Department of Environment and Local Government
P. O. Box 6000
Fredericton, N.B. E3B 5H1
Tel.: (506) 444-5955
Fax: (506) 457-7333
Email: george.haines@gnb.ca

Perry Haines, Director
Approvals Branch
New Brunswick Department of Environment and Local Government
P. O. Box 6000
Fredericton, N.B. E3B 5H1
Tel.: (506) 453-2235
Fax: (506) 457-7805
Email: perry.haines@gnb.ca

Denys Lanteigne, General Director
Partnership for Integrated Management of the Caraquet Bay Watershed Inc.
42D boul. St -Pierre Ouest
Caraquet, N.B. E1W 1B6
Tel: (506) 727-4543
Fax: (506) 727-4532
Email: info@baiedecaraquet.com

Carole LeBlanc
Centre for the Environment of the Acadian Peninsula and its Surroundings Inc.
P.O. Box 3064, Station Main
Tracadie-Sheila, N.B. E1X 1G5
Tel: (506) 395-6856
Fax: (506) 395-6856 (please call before)
E-mail: environnement@nb.aibn.com

George Lindsay, Provincial Manager
Environmental Protection Branch
Environment Canada
77 Westmorland Street, Suite 450
Fredericton, N.B. E3B 6Z3
Tel.: (506) 452-3286
Email: george.lindsay@ec.gc.ca

Dr. Scott MacKnight, President
OCL Group
47 North Street
Dartmouth, N.S. B2Y 1B7
Tel. (902) 463-0114
Fax: (902) 466-5743
Email: ocl@accesscable.net

James McClare, Senior Engineer
James McClare Consulting
527 Beaverbrook Court, Suite 409
Fredericton, N.B. E3B 1X6
Tel. (506) 462-0002
Fax: (506) 462-0003
Email: jmcclare@nbnet.nb.ca

Inka Milewski, Marine Science Advisor
New Brunswick Conservation Council
254 Douglasfield Rd.
Miramichi, N.B. E1N 4S5
Tel.: (506) 622-2460
Fax: (506) 622-2438
Email: milewski@nbnet.nb.ca

José Antonio Molina, Environmental Engineer
ADI Systems Inc.
1133 Regent St., Suite 300
Fredericton, N.B. E3B 3Z2
Tel.: (506) 452-7307
Fax: (506) 452-7308
Email: jam2@adi.ca

Chris Murray, Technical Sales Representative
Epsilon Chemicals
Suite 200, 14 Court St.
Truro, N.S. B2N 3H7
Tel.: (902) 670-1885
Fax: (902) 893-7695
Email: chrismurray@echem.ca

James Murray, NRC-IRAP
2 Garland Court
Incutech, Bldg #1, Room 101
Fredericton, N.B. E3B 5G4
Tel.: (506) 451-6069
Fax: (506) 452-3827
Email: james.murray@nrc-cnrc.gc.ca

Lise Ouellette, Research and Innovation Co-ordinator
University of Moncton (Shippagan campus)
218 boulevard J.-D.-Gauthier,
Shippagan, N.B. E8S 1P6
Tel.: (506) 336-3623
Fax: (506) 336-3478
Email: louellet@umcs.ca

Réginald Paulin, Mayor
Town of Lamèque, City Hall
Lamèque, N.B. E8S 1P6
Tel.: (506) 344-3222
Fax: (506) 344-3266
Email: hplameque@nb.aibn.com

Dr. Sylvain Poirier, General Director
Marine Products Research and Development Centre Inc. (Shippagan)
218 boulevard J.-D.-Gauthier
Shippagan, N.B. E8S 1P6
Tel.: (506) 336-9618
Fax: (506) 336-0321
Email: spoirier@umcs.ca

Jean Robichaud, Plant Manager
Pêcheries St.-Paul Ltée.
P.O. Box 5572
Caraquet, N.B. E1W 1B7
Tel : (506) 727-7247
Fax: (506) 727 2083

Vincent Robichaud, President
Coalition for the Viability of the Environment of Shippagan and the Islands of Lamèque and Miscou
28 rue de l'Hôpital
Lamèque, N.B. E8T 1C3
Tel: (506) 344-3222
Fax: (506) 344-3266
Email: comite.havre@nb.aibn.com

Jochen Schroer, Environmental Engineer, President
Natech Environmental Services
109 Patterson Rd.
Harvey Station, N.B. E6K 1L9
Tel.: (506) 366-1080
Fax: (506) 366-1090
Email: natech@nbnet.nb.ca

Danny Stymiest, Engineer (Industrial Unit)
Approvals Branch
New Brunswick Department of Environment and Local Government
P. O. Box 6000
Fredericton, N.B. E3B 5H1
Tel.: (506) 453-6532
Fax: (506) 457-7805
Email: danny.stymiest@gnb.ca

Nadia Tchoukanova, Chemist
Marine Products Research and Development Centre Inc. (Shippagan)
218 boulevard J.-D.-Gauthier
Shippagan, N.B. E8S 1P6
Tel.: (506) 336-9618
Fax: (506) 336-0321
Email: nadia@umcs.ca

Nancy Turcotte
S.O.S. Baie de Lamèque, Inc.
39 rue du Rivage
Lamèque, N.B. E8T 1L7
Tel. : (506) 344-9089
Email: nancy_turcotte@yahoo.ca

Paul Vienneau,
Professional Shellfish Growers Association of New Brunswick
Tel : (506) 336-2026
Fax : (506) 336-8026

Roger Ward
Sauvons-nos-rivières Committee of Néguac
7 rue Augustin-Sud
Néguac, N.B. E9G 1B2
Tel: (506) 776-9090
Fax: (506) 776-3975
Email: rogerjrw@nbnet.nb.ca

Andy D. Woyewoda, Industrial Technology Advisor
Industrial Research Assistance Programme
National Research Council of Canada (NRC)
P.O. Box 1000, DALTECH Campus
Halifax, N.S. B3J 2X4
Tel.: (902) 426-4670
Fax: (902) 426-4920
Email: andy.woyewoda@nrc-cnrc.gc.ca

Fisheries and Oceans Canada

Gulf Region

Fisheries and Oceans
P.O. Box 3050
Moncton, N. B. E1C 9B6

Mike Chadwick	(506) 851-6206	chadwickm@dfo-mpo.gc.ca
Rhéal Boucher	(506) 395-7702	boucherr@dfo-mpo.gc.ca
Pierre Mallet	(506) 851-3012	malletp@dfo-mpo.gc.ca
Sophie Bastien-Daigle	(506) 851-2609	bastien-daigles@dfo-mpo.gc.ca
Ross Alexander	(506) 851-6251	alexanderr@dfo-mpo.gc.ca
Simon Courtenay	(506) 851-6709	courtenays@dfo-mpo.gc.ca
Pierre Gautreau	(506) 851-6833	gautreaup@dfo-mpo.gc.ca
Catherine Vardy	(506) 851-3179	vardyc@dfo-mpo.gc.ca
Tasha Laroche	(506) 851-2978	larochet@dfo-mpo.gc.ca
Venitia Joseph	(506) 851-6475	josephv@dfo-mpo.gc.ca
Chris Morry	(506) 851-3338	morrycj@dfo-mpo.gc.ca

Fisheries and Oceans
Area Office
3267 rue Principale
P.O. Box 3420, Station Main
Tracadie-Sheila (N.-B.) E1X 1G5

Ernest Ferguson	(506) 395-7722	fergusone@dfo-mpo.gc.ca
Anne Turcotte	(506) 395-7700	turcottea@dfo-mpo.gc.ca

Maritimes Region

St. Andrews Biological Station
531 Brandy Cove Rd.
St. Andrews, N.B. E5B 2L9

John Castell	(506) 529-5904	castellj@dfo-mpo.gc.ca

Headquarters

Fisheries and Oceans
200 Kent St.
Ottawa, Ontario K1A 0E6

Steve Samis	(613) 990-31113	samiss@dfo-mpo.gc.ca

Appendix B: List of Sponsors and Contributors

Fisheries and Oceans Canada | Pêches et Océans Canada | Canada

Environment Canada | Environnement Canada | Canada

Brunswick — Environment and Local Government

Brunswick — Agriculture, Fisheries and Aquaculture

National Research Council Canada | Conseil national de recherches Canada
Industrial Research Assistance Program | Programme d'aide à la recherche industrielle

Atlantic Canada Opportunities Agency

UNIVERSITÉ DE MONCTON
Campus de Shippagan

Centre for Coastal Studies and Aquaculture

UNB

Southern Gulf of St. Lawrence Coalition on Sustainability

- ★ **Coalition for the Viability of the Environment of Shippagan and the Islands of Lamèque and Miscou**
- ★ **N.B. Seafood Processors Association**

Marine Products Research and Development Centre Inc.

Appendix C: Websites and Other Sources of Information

ABL Environmental Consultants Ltd.
http://www.ablenvironmental.com/

Acadia Centre for Estuarine Research
http://ace.acadiau.ca/science/cer/

Acadian Seaplants Ltd.
http://www.acadianseaplants.com/gag.html

ACAP - Atlantic Coastal Action Programme
http://www.ns.ec.gc.ca/community/acap/index_e.html

ACAP Humber Arm
http://www.acaphumberarm.com

ACAP Miramichi
http://www.ns.ec.gc.ca/community/acap/miramichi_river.html

ADI Group Inc.
http://www.adi.ca/

Aquabiotech Inc.
http://www.aquabiotech.ca/English_Introduction/English_Introduction.html

Atlantic Canada Opportunities Agency
http://www.acoa.ca/e/index.shtml

Canadian Fishery Consultants Ltd.
Canadian Aquaculture Industry Alliance
http://www.aquaculture.ca/EnglishWeb.html

http://www.canfish.com/canfish/index.htm

Canadian Food Inspection Agency
http://www.inspection.gc.ca/english/toce.shtml

Conservation Council of New Brunswick
http://www.web.net/~ccnb/

Daltech – Dalhousie University
http://www.cte.dal.ca/

Environment Canada
http://www.ec.gc.ca/envhome.html

Epsilon Chemicals Ltd.
http://www.echem.ca/

Fisheries and Oceans Canada
http://www.dfo-mpo.gc.ca/home-accueil_e.htm

Fisheries Council of Canada
http://fisheriescouncil.ca/fcc.htm

Fraser River Action Plan (BEIMP and FREMP)
http://www.bieapfremp.org/

Island Fishermen Co-operative Assoc. (l'Association Coopérative des Pêcheurs de l'Île)
http://www.fisherman-coop.com/eng/associ/associ.html

James McClare Consulting
http://www.chemconsultants.org/jmcclare.html

Le Partenariat pour la gestion intégrée du bassin versant de la baie de Caraquet
http://www.baiedecaraquet.com/somme.htm

Marine Products Research and Development Centre Inc. (MPRDC)
http://crdpm.cus.ca/

NATECH Environmental Services Inc.
http://www.natech.nb.ca/

National Programme of Action (NPA)
http://www.npa-pan.ca/index_e.htm

National Research Council – Industrial Research Assistance Programme
http://irap-pari.nrc-cnrc.gc.ca/english/content_notices_e.html

New Brunswick Community Colleges
http://www.nbcc.nb.ca/defaulte.htm

New Brunswick Department of Agriculture, Fisheries and Aquaculture
http://www.gnb.ca/0027/Index-e.asp

New Brunswick Department of Environment and Local Government
http://www.gnb.ca/0009/index-e.asp

NovaTec Consultants Inc.
http://www.novatec.ca/

OCL Group (Scott MacKnight)
http://www.oclgroup.com/

Peat Research and Development Centre
http://www.crdt.cus.ca/

Rawdon Technologies Ltd.
http://rawdontechnologies.com/

Roy Consultants Group
http://www.grouperoy.com/

Shediac Bay Watershed Association
http://www.sbwa-abvbs.net/

Southern Gulf of St. Lawrence Coalition on Sustainability
http://www.coalition-sgsl.ca/main/indexe.htm

TankDoctor Aquatic Systems Inc.
http://www.tankdoctor.ca

TAVEL Ltd.
http://www.tavel.ca/home.html

Town of Lamèque
http://lameque.acadie.net/

Town of Shippagan
http://i-web.net/shippagan/

Trident Seafoods Ltd. (Paul Bourke)
http://www.tridentseafoods.com/

University of Moncton – Shippagan campus
http://www.cus.ca/index/index.cfm

University of New Brunswick – Centre for Coastal Studies and Aquaculture
http://www.unbsj.ca/coastal/

Zenon Environmental Inc.
http://www.zenonenv.com/

Centre for the Environment of the Acadian Peninsula and Its Surroundings Inc.
Box 3064, Station Main
Tracadie-Sheila, N.B. E1X 1G5
Tel.: (506) 395-6856
Email: environnement@nb.aibn.com

Coalition for the Viability of the Environment of Shippagan and the Islands of Lamèque and Miscou
28 rue de l'Hôpital
Lamèque, N.B. E8T 1C3
Tel.: (506) 344-3222
Fax: (506) 344-3266
Email: comité.havre@nb.aibn.com

Ecological Park of the Acadian Peninsula
28 rue de l'Hôpital
Lamèque, N.B. E8T 1C3
Tel.: (506) 344-3223
Fax: (506) 344-3266
Email: slameque@nb.aibn.com

New Brunswick Seafood Processors Association
1133 St. George Blvd., Suite 420
Moncton, N.B. E1E 4E1
Tel.: (506) 857-3056 T
Fax: (506) 857-3059 F
Email: nbspa@cme-mec.ca

Professional Shellfish Growers Association of New Brunswick
220 St. Pierre Blvd. West
Office 210
Caraquet, N.B. E1W 1A5
Tel.: (506) 727-0886
Fax: (506) 727-5286
Email aqua@nb.aibn.com

Sauvons-nos-rivières Committee of Néguac
7 rue Augustin-Sud
Néguac, N.B. E9G 1B2
Tel.: (506) 776-9090
Fax: (506) 776-3975
Email: rogerjrw@nbnet.nb.ca

Seasprings Industries Inc.
102 Victoria St.
Amherst, N.S. B4H 1X8
Tel.: (902) 667-6061
Fax: (902) 667-6062
Email: seaspringsinc@canada.com

SOS Baie de Lamèque
58 rue Principale
Lamèque, N.B. E8T 1M6
Tel.: (506) 344-7498
Email: info@sosbaiedelameque.com

Appendix D: Project Team

Co-Champions:

Mike Chadwick, Regional Director, Oceans and Science, DFO
George Haines, Assistant Deputy Minister, Environmental Management, NBDELG
George Lindsay, Provincial Manager, Environmental Protection, EC

Scientific and Technical Programme:

John Castell, Research Scientist (retired), DFO
Thierry Chopin, Chair, Department of Biology, CCSA/CEMAR UNB-Saint John
Angélina Cool, Executive Director, N.B. Seafood Processors Association
Simon Courtenay, Section Head, Environmental Sciences, DFO
Andy Woyewoda, Industrial Technology Advisor, NRC-IRAP

Project Management:

Louis Arsenault, Director, Commercial Fisheries Development, NBDAFA
Perry Haines, Director, Approvals Branch, NBDELG
Venitia Joseph, Biologist, Environmental Sciences, DFO
Pierre Mallet, Environmental Biologist, Policy and Programme Planning, DFO
Chris Morry, Senior Advisor, Oceans and Habitat, DFO

Local Arrangements and Community Involvement:

Sophie Bastien-Daigle, Environmental Biologist, Stewardship, DFO
Ernest Ferguson, Area Habitat Biologist, DFO
Sylvain Poirier, General Director, Marine Products R&D Centre, Inc.

Communications:

Pierre Gautreau, Communications Advisor, Communications, DFO
Catherine Vardy, Science Liaison, Oceans and Science, DFO

Appendix E: Workshop Programme

Tuesday, February 25

08:30 REGISTRATION

09:00 Welcome and Opening Address – Mike Chadwick (DFO) /George Lindsay (EC)/ George Haines (NBDELG)

Morning theme: What are the impacts of fish plants on coastal environments of the southern Gulf of St. Lawrence?
Chair: Louis Arsenault

09:30 Management of seafood processing waste in the Atlantic region
Jeffrey Corkum (Environment Canada)

10:00 Lamèque Bay Environmental Management Study
Scott MacKnight (OCL Group)

10:30 HEALTH BREAK

11:00 An industry perspective
Angélina Cool (N.B. Seafood Processors Association)

11:30 Regulatory context: How are fish plants regulated now?
Perry Haines (NBDELG)

12:00 Ecological impacts of nutrient loading in coastal ecosystems
Inka Milewski (N.B. Conservation Council)

12:30 LUNCH

Afternoon Theme: What can be done to reduce environmental impacts?
Sub theme A: In-plant modifications & material recovery
Chair: Sylvain Poirier

13:30 Maximizing return from seafood processing waste & effluent management
Andy Woyewoda (NRC-IRAP, Halifax)

14:00 In house approaches to pollution prevention in the seafood processing industry
James McClare (James McClare Consulting)

14:30 B.C. seafood plant experience with effluents
Paul Bourke (Trident Seafoods, B.C.)

15:00 HEALTH BREAK

15:30 Integrated management of residues and wastewaters
Nadia Tchoukanova (Marine Products R&D Centre, Shippagan)

15:45 The importance of water-pinching
Mauricio González (Marine Products R&D Centre, Shippagan)

16:00 Flocculated system technologies and application to fish meal plants
Chris Murray (Epsilon Chemicals, Truro N.S.)

16:30 Panel discussion on in-plant modifications.
Moderator: John Castell

Panel members:
- **Speakers**

17:00 Wine and cheese reception hosted by
Coalition for the Viability of the Environment of Shippagan and the Islands of Lamèque and Miscou
University cafeteria.

Wednesday, February 26

Morning Theme: What can be done to reduce environmental impacts?
Sub theme B: End-of-pipe applications
Chair: Simon Courtenay

09:00 Biological wastewater treatment alternatives for the seafood processing industry
José Molina (ADI Systems Inc.)

09:30 Approaches to wastewater treatment - Lagoons, odour problems and Zenon technology
Graham Gagnon (Daltech)

10:00 Panel discussion on end of pipe applications
Moderator: Thierry Chopin (UNB Saint John)

Panel members:
- **Speakers**

10:30 HEALTH BREAK

Morning Theme: What can be done to reduce environmental impacts?
Sub theme C: Receiving Environment Applications
Chair: Simon Courtenay

11:00 Could the aquaculture of shellfish and seaweed work with fish plant effluents as it works with finfish aquaculture?
Thierry Chopin (UNB Saint John)

11:30 Gauging the assimilative capacity of coastal receiving environments
Graham Daborn and Mike Brylinsky (Estuarine Research Centre, Acadia U.)

12:00 Considerations in an ocean outfall design
Jochen Schroer (NATECH Environmental Services Inc.)

12:15 Panel discussion on receiving environment applications
Moderator: Andy Woyewoda

Panel members:
- **Speakers**

13:30 **Panel Discussion:**
Directions and mechanisms to move forward
Moderator: Simon Courtenay (DFO)

Panel members:

- **Andy Woyewoda (NRC-IRAP)**
- **Mike Chadwick (DFO-Moncton)**
- **George Lindsay (EC-Fredericton)**
- **Lise Ouellette (UdeM-Shippagan)**
- **Sylvain Poirier (MPRDC-Shippagan)**
- **Harry Collins (sGSL Coalition on Sustainability-Moncton)**
- **Angélina Cool (N.B. Seafood Processors Association-Moncton)**
- **Louis Arsenault (NBDAFA-Fredericton)**

14:30 **Summary of the Workshop and General Discussion on the Way Ahead**

- **Mike Chadwick (DFO)**
- **George Lindsay (EC)**
- **George Haines (NBDELG)**
- **All Attendees**

15:00 **ADJOURNMENT**